MARCH-APRIL 1961

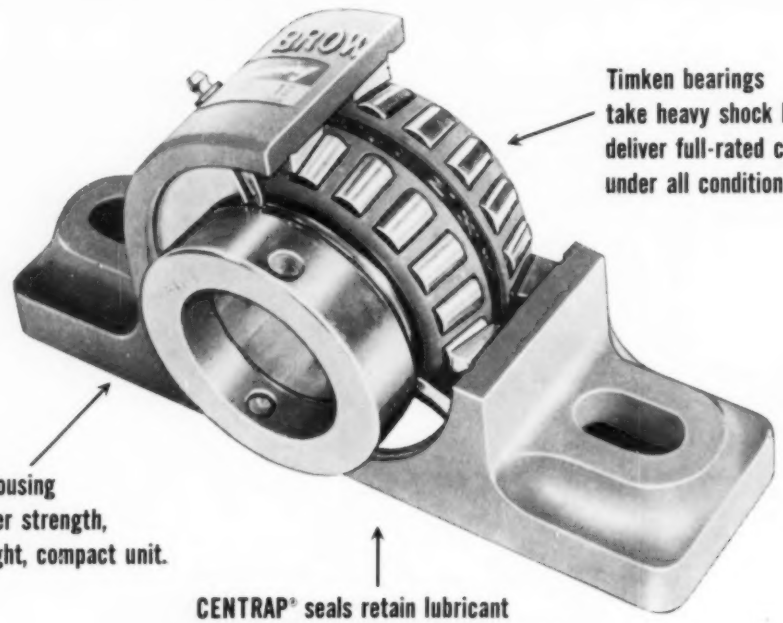
ORDNANCE

LAND • SEA • AIR • SPACE

Davy Crockett—atomic infantry weapon

In this issue: Gen. Thomas D. White • R. W. Henderson • Russell A. Crist • T. M. Robertson
D. B. Webster, Jr. • F. Fischer • R. S. Sartoris • U. M. Staebler • V. A. Lamb • J. P. Young

Browning malleable housings team up with Timken® bearings for greater capacity and strength



To be sure their PB900 pillow block has maximum ability to take heavy loads, Browning Manufacturing Company, Maysville, Kentucky, uses a malleable housing and Timken® tapered roller bearings. The malleable housing permits a stronger yet lighter, more compact unit. The Timken bearings provide higher load-carrying capacity and longer life in minimum space—more than any other type of bearing.

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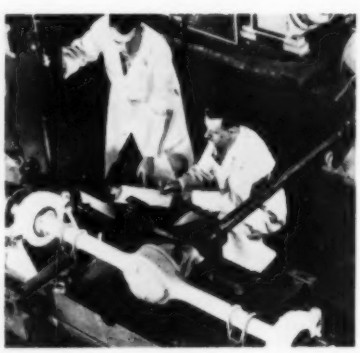

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ORDNANCE

LAND • SEA • AIR • SPACE

Forty-one Years of Leadership in American Armament Preparedness

VOL. XLV MARCH-APRIL 1961 NO. 245

The Cover.—The jeep-mounted Davy Crockett recoilless rifle is one of the Army's latest front-line infantry weapons. It can fire an atomic warhead and can be hand-carried by a crew of three if the situation demands (Army photo).

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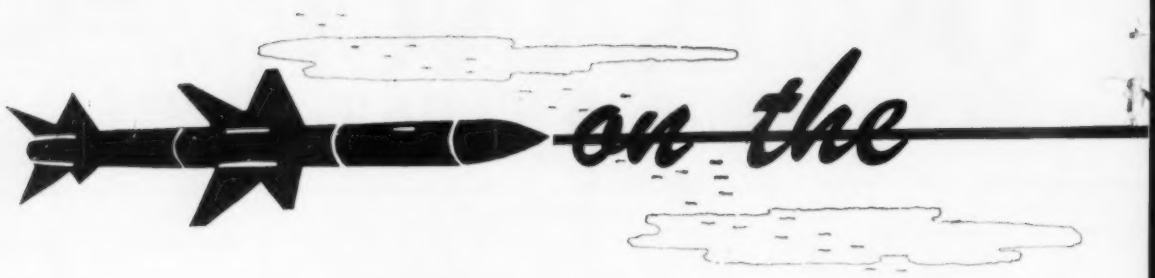


THE CONTENTS OF THIS ISSUE IN BRIEF

Aerospace Power Today (p. 620) . . . . What must the United States do to maintain a dominant military posture? Gen. Thomas D. White, Chief of Staff of the U. S. Air Force, says we must maintain effectively armed military forces in being and at the same time develop powerful new weapons to prevent the possibility of a "technological Pearl Harbor."

Making Nuclear Weapons (p. 623) . . . . "Penetration to the target may be very difficult; therefore the bomb or warhead that does get there had darn well better explode!" So says R. W. Henderson of Sandia Corporation who here tells the necessity of high-order quality in nuclear arms production. Quality cannot be inspected into a product at the end of the line—it must be built in.

Production and Policy (p. 626) . . . . If there is any possibility that present industrial practices are conducive to waste and unnecessary expense in the manufacture of defense equipment they must be replaced with the elements of competition, the prospect of profit, and the risk of loss, says Russell A. Crist, Director of the Defense Department Office of Production Policy.

Program for Preparedness (p. 633) . . . . The American Ordnance Association has a fourfold plan to ensure armament readiness for the United States, according to Louis Polk, past president of the Association. This program includes initiative in research and development, the recognition of industry's defense role, increased technical education, and popular understanding of the need for preparedness.

Production of America's Defense Weapons (pp. 634-642) . . . . A résumé of the papers given during the technical seminars of the Forty-second Annual Industrial Preparedness Meeting of the Association held at the Waldorf-Astoria Hotel, New York City, December 7, 1960. These papers were given by leaders of the Science-Industry-Ordnance Team and discussed "Production for the Army" (p. 634), "Production for the Navy" (p. 637), and "Air Force Production" (p. 640). The other articles preceding this group also were addresses or statements given at the Annual Meeting.

Battle under the Sea (p. 645) . . . . The covering cloak of concealment offered by the oceans makes them our most critical battlefields today. Here in the deep, Author T. M. Robertson says, will lurk the ballistic-launching submarines of the enemy.

Much remains to be done in developing our underwater guided missiles, offspring of the trusty torpedo, but there must be a break-through in target detection, and a way must be discovered to monitor the vast ocean areas.

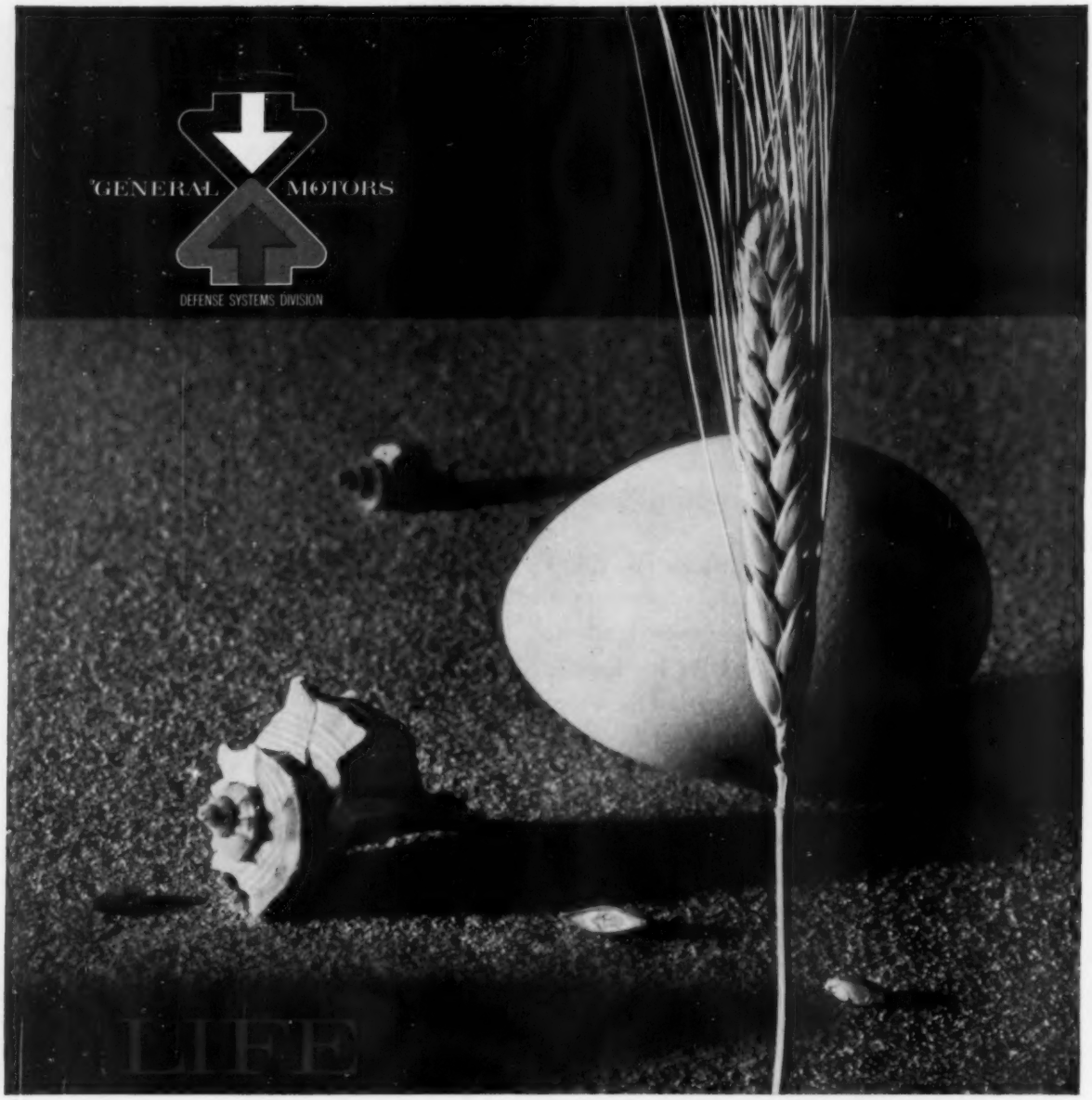
The Revolving Cannon (p. 651) . . . . Although the Civil War was fought principally with muzzle-loading rifles and single-shot artillery, some unique ideas for increased firepower in the form of quick-firing cannon were proposed. However, as Donald B. Webster, Jr., shows here, technology in those days was not equal to the inventors' ingenuity, and the weapons passed into oblivion.

Combat Vehicle Stability (p. 713) . . . . A mathematical study of the engineering mechanics of simulated firing effects on combat vehicles which makes an interesting approach to the problem of achieving accurate fire control in our fighting tanks. F. Fischer of the Research Division, Ordnance Tank-Automotive Command, makes a scholarly presentation.

Our Arctic Watchdog (p. 717) . . . . The shortest distance between potential enemy missile bases and the heartland of the United States lies over the North Pole. To prevent a surprise ICBM attack from this direction, huge early-warning radars have been built at Thule, Greenland, which will give the North American Air Defense Command time to cage, if not tame, the hostile weapons, according to Author Robert S. Sartoris.

Nuclear Power Plants (p. 721) . . . . Even in the largely experimental state of the art today it is believed that nuclear power could be competitive with power from fossil-fueled plants under certain conditions. Ulysses M. Staebler of the Atomic Energy Commission explains the objectives of the Civilian Nuclear Power Program which aims to permit production of nuclear power at low cost.

Plating Gun Bores (p. 725) . . . . Due to the higher velocities and greater rate of fire of our modern weapons the barrels often are short-lived, but recent experiments show that a thick plating of chromium can increase barrel life as much as five times, according to Coauthors Vernon A. Lamb and John P. Young of the National Bureau of Standards.



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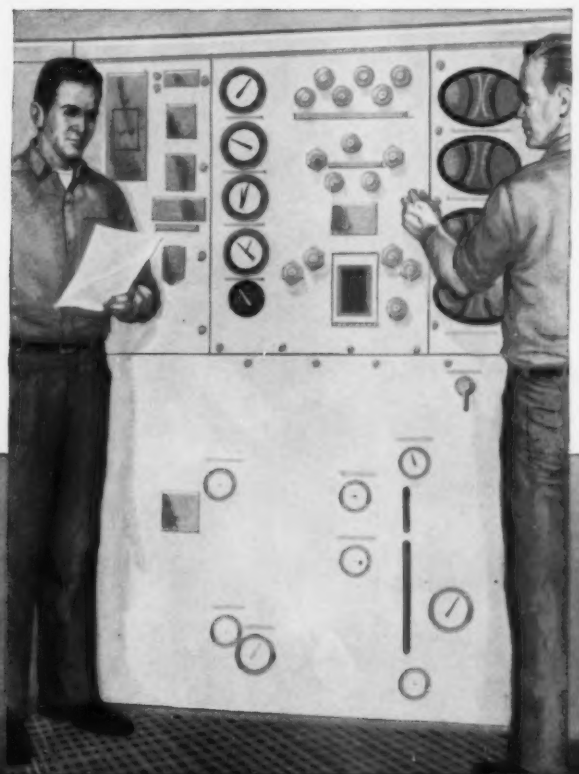

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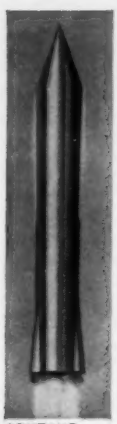
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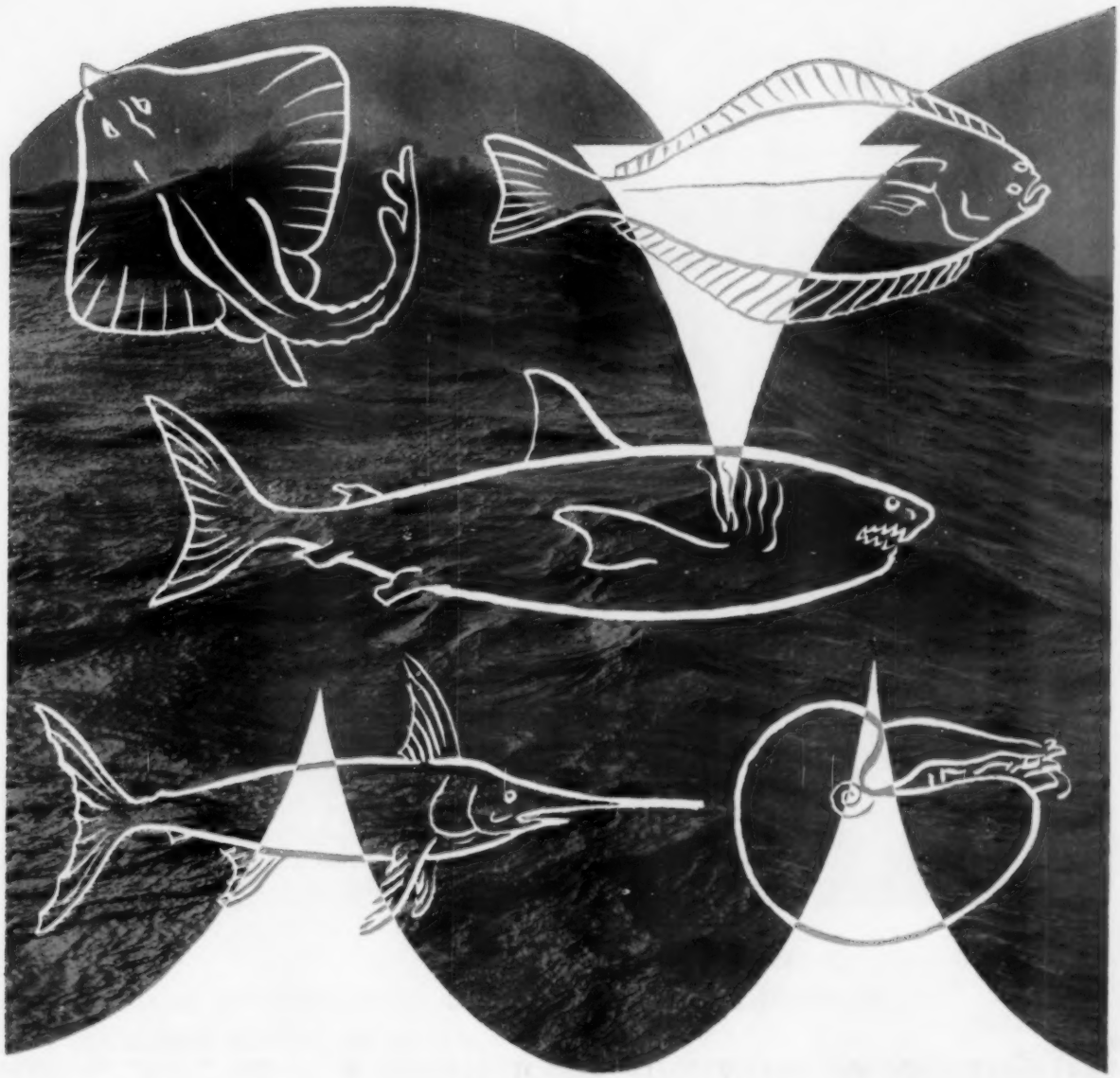

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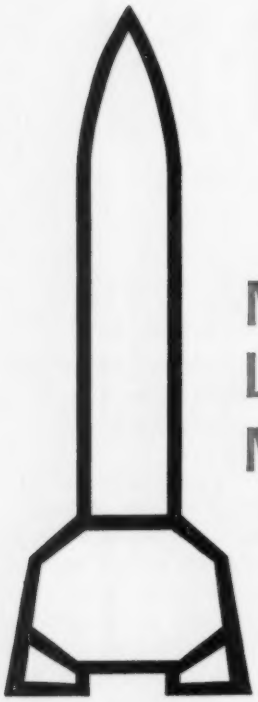
...since 1911

Top to bottom: 79th Inf. Division, Electronics Technician 3 (Navy), 9th Bombardment Group, Staff Sergeant's chevrons, Third Inf. Division, 15th Bombardment Group, Navy Squadron VF-6.



MISSILE LAUNCHER MADE MOBILE-LIGHT, TAKEOFF-TOUGH WITH

N-A-XTRA

HIGH-STRENGTH STEEL

A battlefield might be anywhere. Wherever it is, there may be a need for the new 10,000-pound, 36-foot Sperry-Rand U.S. Army Sergeant missile. That's why the launching station on which the missile is assembled, aimed and fired must be light enough to be transported by land, sea or air. Yet it also has to be rugged and strong enough to assure the launcher's availability for subsequent firing.

N-A-XTRA steels meet all the conditions of light weight, high strength and impact resistance. Pound for pound, they're nearly three times stronger than mild carbon steel. They are used, not only in this mobile missile launcher, but in many other defense products and in commercial equipment such as earth-moving vehicles, heavy machinery and pressure vessels.

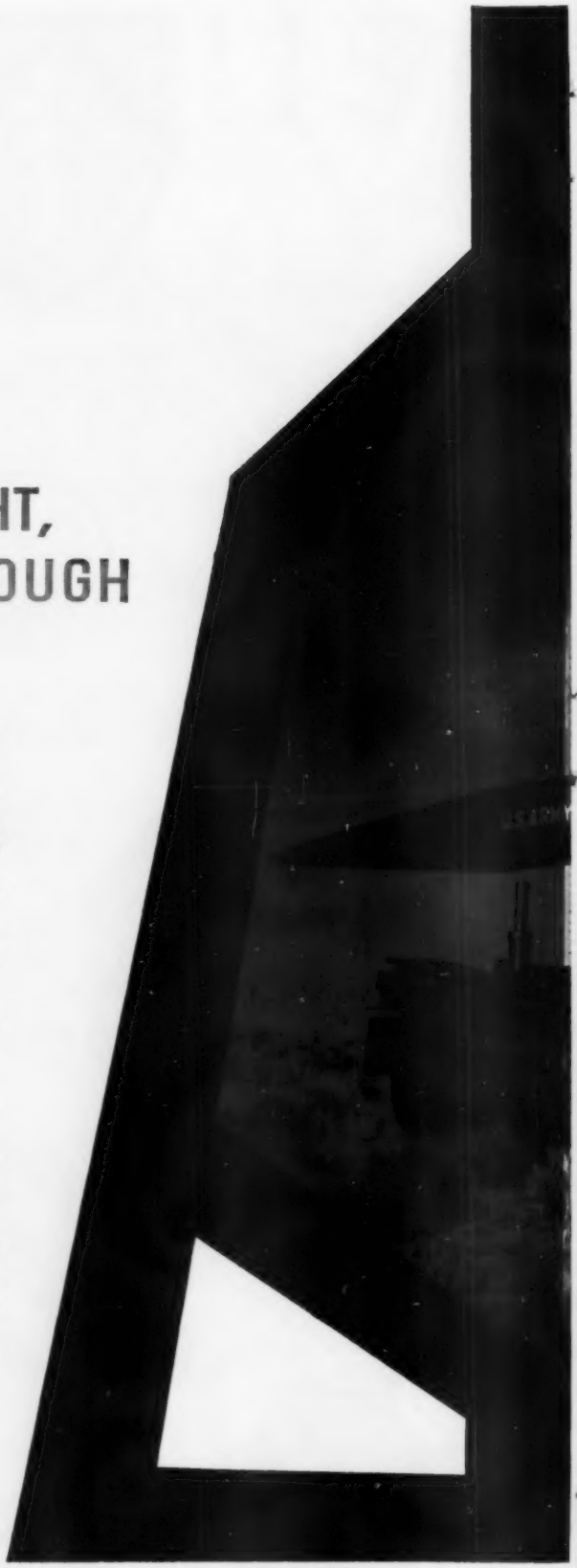
Fabrication qualities are an N-A-XTRA bonus. Even at extreme subnormal temperatures, they remain tough and readily weldable. Conventional methods—cold forming, gas cutting, shearing and machining—give superior results, too. For further information, write Product Development Department, Great Lakes Steel Corporation, Detroit 29, Michigan.

N-A-XTRA

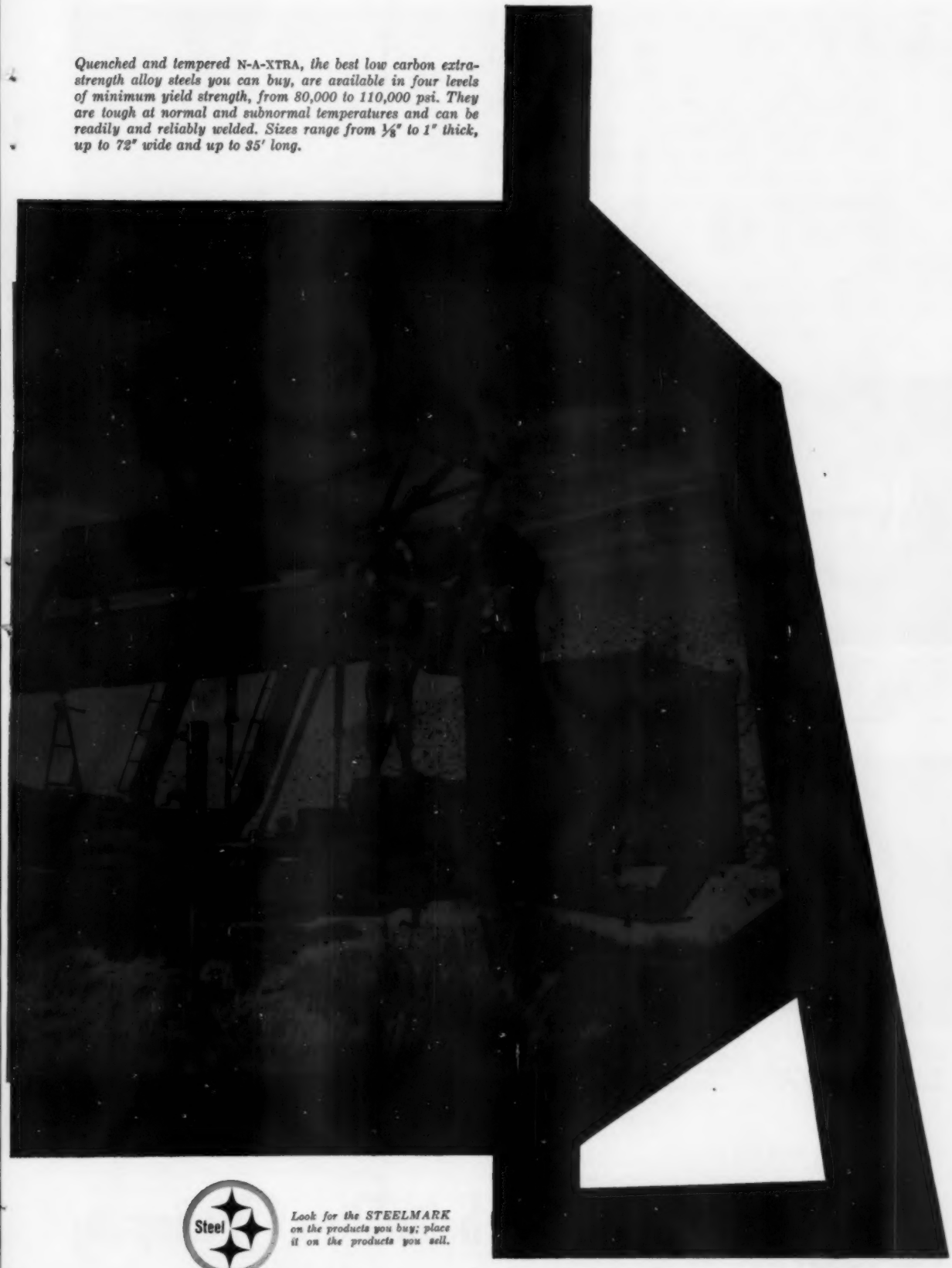
A PRODUCT OF

GREAT LAKES STEEL

Detroit 29, Michigan



Quenched and tempered N-A-XTRA, *the best low carbon extra-strength alloy steels you can buy, are available in four levels of minimum yield strength, from 80,000 to 110,000 psi. They are tough at normal and subnormal temperatures and can be readily and reliably welded. Sizes range from ⅛" to 1" thick, up to 72" wide and up to 35' long.*



Steel

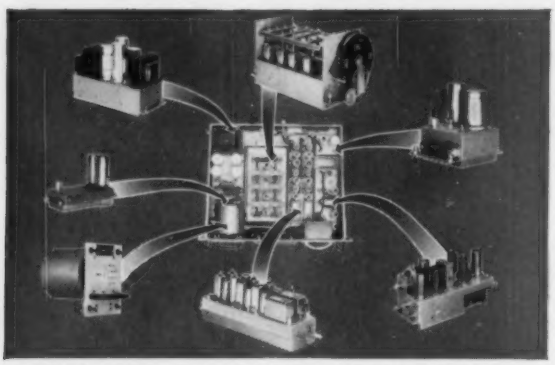
Look for the STEELMARK on the products you buy; place it on the products you sell.

Great Lakes Steel is a Division of **NATIONAL STEEL CORPORATION**

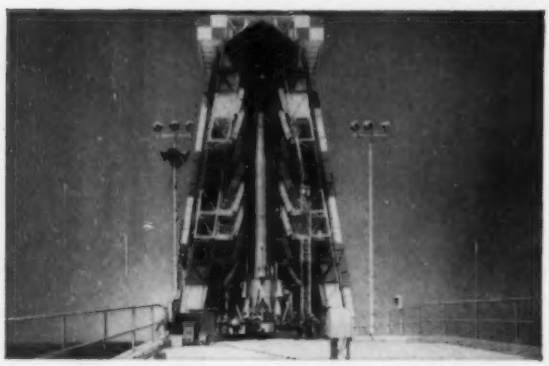
For more than a quarter century, Hallicrafters has worked in close partnership with our armed forces on fast solutions to critical military electronics problems. Out of this priceless experience are emerging startling new ideas and hard-hitting, fast-moving techniques to keep our country one jump ahead in electronic warfare . . .

B-52 and other military aircraft will be protected by the most potent Electronic Countermeasures equipments yet devised. These equipments were developed in close teamwork with the Air Force under Hallicrafters' QRC (Quick Reaction Capability) program. Now qualified to meet full environmental specifications, they are in quantity production.

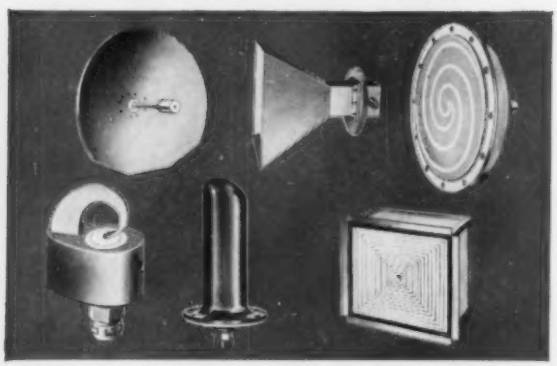
New levels of speed and efficiency are being reached in equipment modernization, retrofit and technical support programs with Hallicrafters' radical new "Blue Streak" project. Specially-trained Maintenance and Technical Support Teams, close-knit and flexible, can be tactically deployed to accomplish maintenance, installation and testing of electronics weapons systems anywhere in the world.



Hallicrafters communications leadership is exemplified by new high frequency Single Sideband receiver, (model no. SX-116). 100% modular design permits simple modification for compatability with existing and future communications systems. Stability, with proper available plug-ins, is better than one part in 10,000,000 per month. Hallicrafters also offers an existing capability in receiving and transmitting techniques up to frequencies of 50,000 megacycles.



Hallicrafters participation in the Atlas missile project helped to develop capability for many areas of the complex missile field, including code translator data systems; ground support equipment; ECM testing and antenna systems. Current explorations involve latest Infra Red techniques.



Airborne antennas and micro-wave components with power capability in excess of 1,000 watts, can be made available to solve tomorrow's very high power handling requirements. Testing of microwave components is possible with special high power generators, designed and built by Hallicrafters.

Looking for a challenging new opportunity? We are interested in qualified engineers at all levels. For full details in confidence, contact William F. Frankart, Director of Engineering.

For further information on Hallicrafters facilities and experience in military electronics research, development and production, please write to:

hallicrafters company

Military Electronics Division,
Chicago 24, Illinois

THE NEW M151...
READY FOR THE TOUGHEST MILITARY MANEUVERS!

Tested over 400,000 grueling miles at Aberdeen Proving Grounds and Fort Knox, the M151 Truck, Utility, ¼ ton, 4x4, has met the new, higher reliability goals for wheeled vehicles.

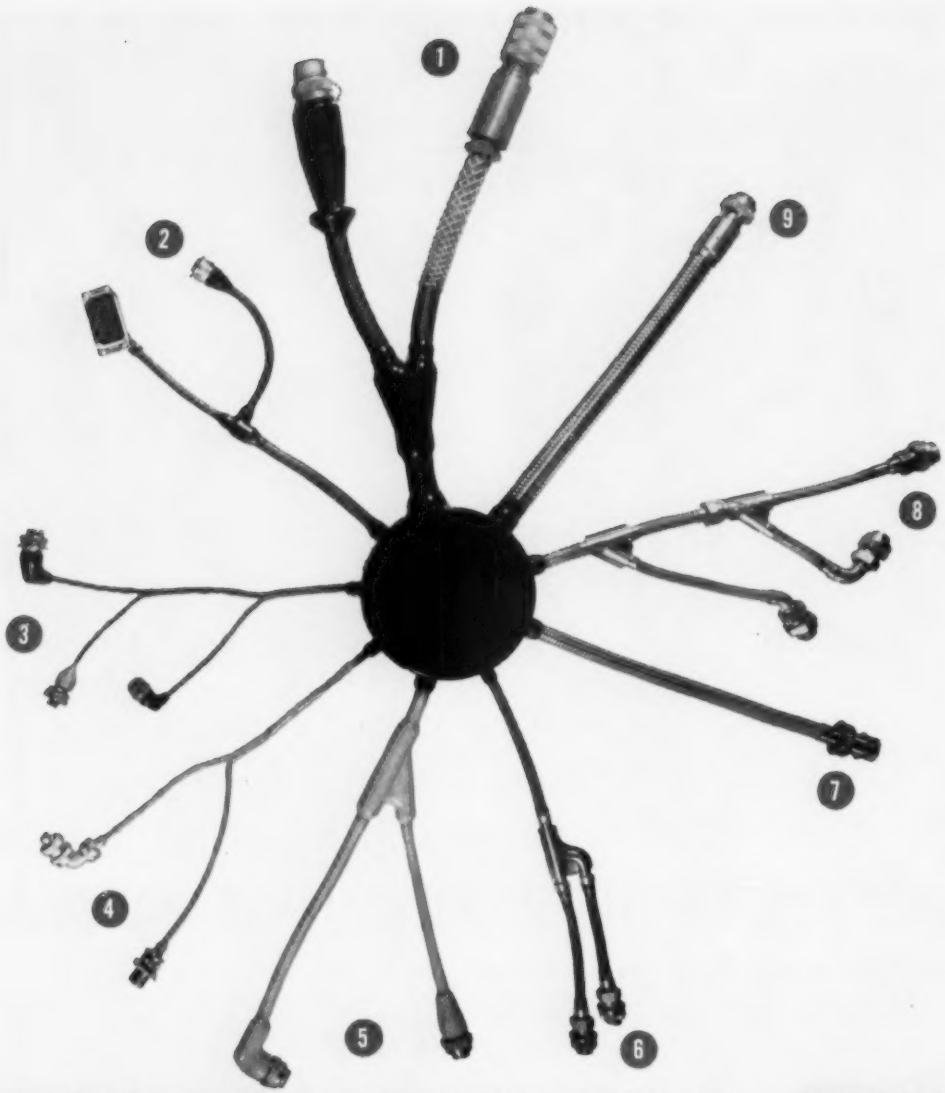
More than eight years of research and engineering in cooperation with Ordnance Tank Automotive Command went into this rugged, lightweight, general purpose personnel and cargo carrier—designed and built by Ford to be superior to any other vehicle in its class!

- **20,000 MILES WITHOUT DEPOT MAINTENANCE!** The M151 scored 90% reliable against the new high standard for wheeled units.
- **26% MORE CARGO SPACE!** The M151 is six inches shorter, height is reduced four inches, yet it easily hauls a 1,200 pound payload.
- **AIR-DROP CAPABILITY!** Saves 1,000 pounds when rigged for parachuting. Chute rigging time cut drastically.
- **EXTREME WEATHER PERFORMANCE!** Starts and performs at temperatures from 65° below zero to 125° above.
- **FORDS DEEP WATER!** Snorkel tubes with sealed engine and drive components add capability for hard-bottom deep water crossing.
- **EASIER RIDE!** Unitized, welded steel body and frame plus four wheel independent coil suspension absorbs rough road shocks.
- **EXTRA POWER AND RANGE!** New, lighter engine develops 71 hp at 3800 rpm. Newly extended cruising range. Superior acceleration. Excellent fuel economy.
- **CLIMBS 60% GRADE FULLY LOADED!** Sure-footed over rugged terrain with 4-wheel drive and 4-speed synchromesh transmission.

Complete development and production of advanced military vehicles and weapons to meet exacting military demands is a tradition at Ford Motor Company. Imaginative engineering and efficient production are our business.

SPECIAL MILITARY VEHICLES OPERATIONS, DEFENSE PRODUCTS GROUP

Ford
MOTOR COMPANY
DEARBORN, MICHIGAN



TYPICAL BENDIX® SPECIAL-PURPOSE CABLES THAT SOLVE CRITICAL ENVIRONMENTAL PROBLEMS

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2. Benseal® Missile Control Cable
3. Fabric Braided—Aircraft and Missile Control Cable
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7. "Wet Wing" Aircraft Fuel Cell Cable
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Bendix cables—products of over a quarter-century of design and manufacturing experience—are proving their complete reliability in a countless variety of applications involving critical environmental conditions.

BENDIX CABLES • BENDIX CONNECTORS

Designed together to work best together

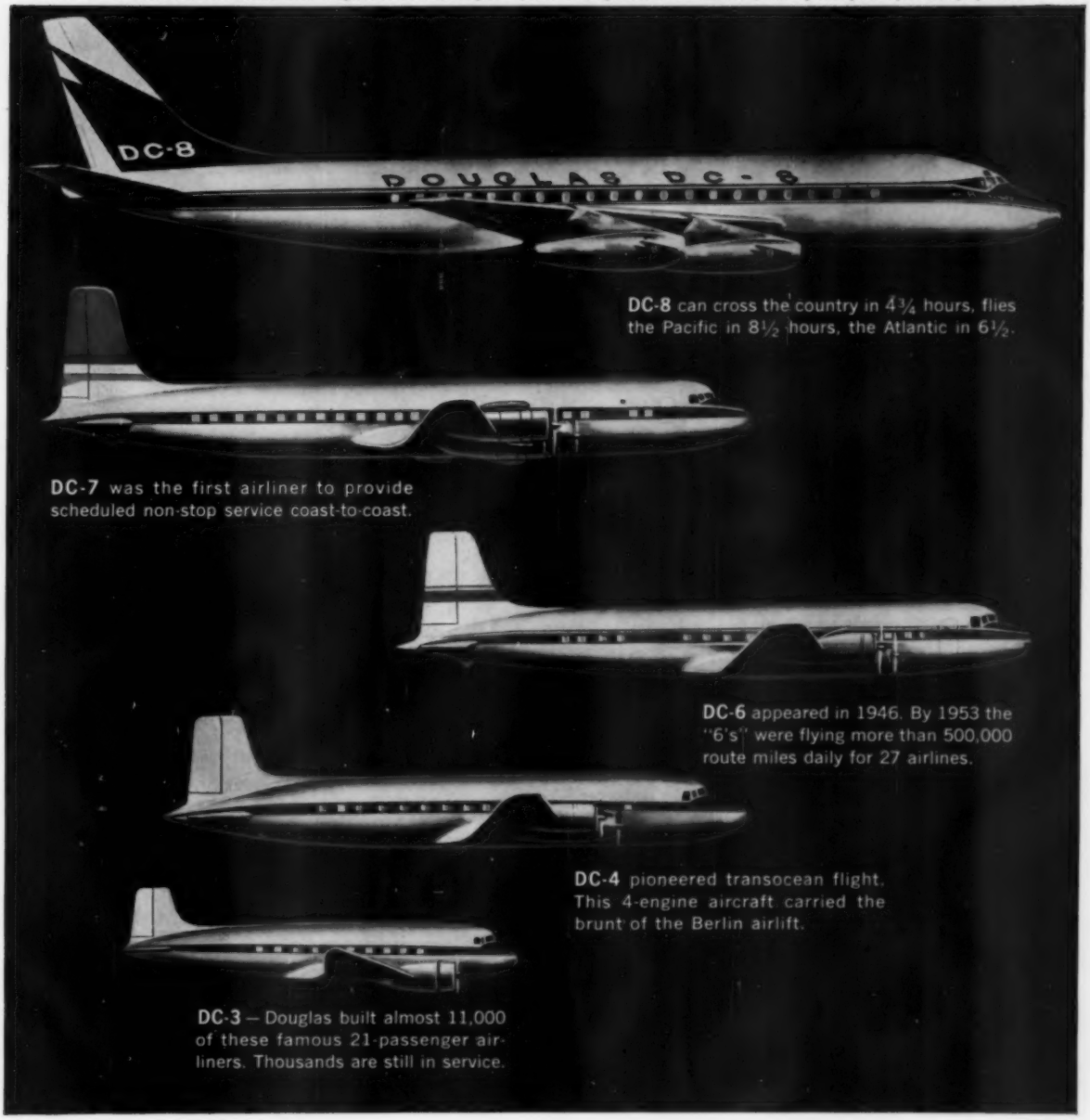
For complete information, write:

Scintilla Division

SIDNEY, NEW YORK

THE Bendix CORPORATION

One of a series of advertisements showing the breadth of Douglas experience being devoted to commercial, military and space-exploration projects.


DC-8
DOUGLAS DC-8
DC-8 can cross the country in 4¾ hours, flies the Pacific in 8½ hours, the Atlantic in 6½.
DC-7 was the first airliner to provide scheduled non-stop service coast-to-coast.
DC-6 appeared in 1946. By 1953 the "6's" were flying more than 500,000 route miles daily for 27 airlines.
DC-4 pioneered transocean flight. This 4-engine aircraft carried the brunt of the Berlin airlift.
DC-3 – Douglas built almost 11,000 of these famous 21-passenger airliners. Thousands are still in service.

Five big steps to a smaller world

How narrow the oceans have become! How small the world! And how quickly the shrinking has occurred!

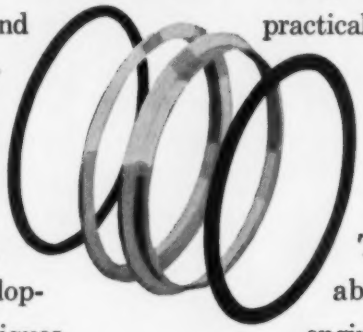
Within a generation, man has stopped wondering if he would ever fly, and now asks how soon he will land on the moon.

Douglas, builder of the 5 great "DC" airliners that did so much to shrink the world you live in, is now at work on the great rockets and rocket ships which will shrink the solar system.

DOUGLAS

MISSILE AND SPACE SYSTEMS • MILITARY AIRCRAFT • DC-8 JETLINERS • TRANSPORT AIRCRAFT • ANTI-SUBMARINE SYSTEMS • AIRCOMB® • GROUND SUPPORT EQUIPMENT

Problem: Sealing of heavy-vehicle track components. *Needed:* A seal to keep lubricant in, dirt, sand, grit and water out. *Produced:* A metal-to-metal, floating ring seal by Caterpillar. The result of basic research in metals, rubber compounds, and lubricants—plus development of new tooling techniques.



This advance in sealing design permits use of more effective lubricants and eliminates expensive day-to-day maintenance.

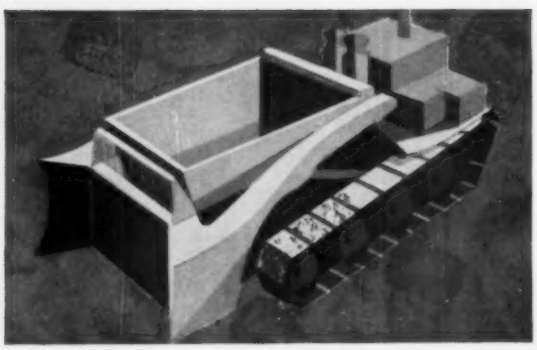
Such developments as this typify Caterpillar capabilities in producing sound, practical solutions for mobility needs.

As a leading producer of heavy equipment, Caterpillar has outstanding resources in research, engineering and manufacturing. This experience and talent are available to you to meet your vehicle, engine, or component requirements.

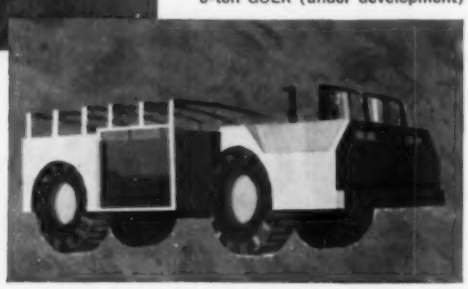
For details of capability, write for Bulletin No. 40-20265. Defense Products Department, Caterpillar Tractor Co., Peoria, Ill.

CAPABILITY IN POWER AND MOBILITY *for defense*

Air-droppable Tractor Bulldozer



Universal Engineer Construction Machine (under development)



8-ton GOER (under development)

CATERPILLAR

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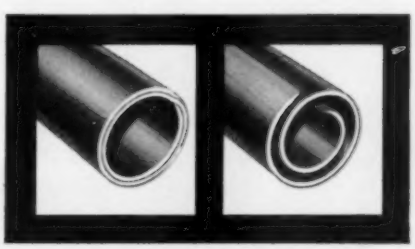
Washington, D. C. Peoria, Illinois

RESEARCH • DEVELOPMENT • MANUFACTURING FOR DEFENSE

Bundy can mass-fabricate practically anything

Your most complex tubing designs are turned into tight tolerance components at Bundy. It's done with Bundyweld®, the tubing for design engineers with special problems. In addition to cutting, burring, flaring and bending, Bundy can expand, swage, flatten, upset, coil, bifurcate or machine this tubing to your specifications. In fact, Bundy can mass-fabricate practically anything. And Bundyweld meets ASTM 254; Govt. Spec. MIL-T-3520, Type III. Our engineers will work with you at any time. Just call, write or wire: Bundy Tubing Company, Detroit 14, Mich.



* * *

Bundyweld, double-walled from a single copper-plated steel strip, is metallurgically bonded through 360° of wall contact. It is lightweight, uniformly smooth and easily fabricated . . . has remarkably high bursting and fatigue strengths. Sizes up to ⅝" O.D.

BUNDY® TUBING COMPANY

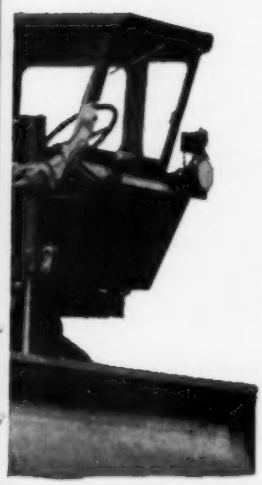
DETROIT 14, MICH. • WINCHESTER, KY. • HOMETOWN, PA.

WORLD'S LARGEST PRODUCER OF SMALL-DIAMETER TUBING. AFFILIATED PLANTS IN AUSTRALIA, BRAZIL, ENGLAND, FRANCE, GERMANY, ITALY, JAPAN.

Rough terrain crane lifts 20 ...weighs only 25 tons

Versatile 20-ton mobile crane equipped with a 30-ft. strut boom. (Not shown, but available as optional equipment are a 30-ft. gooseneck boom and three 20-ft. insert sections.) Unit can be used for normal crane work and also as a light bulldozer, clamshell or dragline. Designed under the auspices of the U. S. Army Engineer Research and Development Laboratories, Ft. Belvoir, Va.

This mark tells you a product is made of modern, dependable Steel.



Built light and strong with USS "T-1" and TRI-TEN Steels.

Designed for Army Engineers' Airborne operations, for transportation by landing craft or overseas railroad, this crane had to be built light. Total weight of the crane was held to 25 tons by utilizing the *extra* high yield strength of USS "T-1" Constructional Alloy Steel and the high strength of USS TRI-TEN Steel.

Three and a half tons of USS "T-1" Steel, with a minimum yield strength of 100,000 psi, were used in the entire frame of the carrier and in portions of the wheels, wheel spindles, dozer, dozer arms and steering linkage. These parts were designed to a working stress of 50,000 psi and helped keep the carrier portion of the crane's weight down to 30,000 pounds; the remaining 20,000 pounds of the crane's total weight are contained in the craning machinery, cab and boom.

LeTourneau-Westinghouse engineers, who designed the carrier, say that it would have been impossible to meet the military weight requirements without this steel. They were pleased with "T-1" Steel's welding characteristics and its reliability throughout the test program.

USS TRI-TEN High Strength Steel, with a minimum yield point of 50,000 psi, was used for the chords of the boom for maximum strength, weldability and weight reduction. The rotating crane unit was designed and built by the American Hoist & Derrick Company under a subcontract from LeTourneau-Westinghouse Company.

United States Steel makes two other high strength steels with minimum yield points of 50,000 psi—USS COR-TEN Brand, noted for strength with superior resistance to atmospheric corrosion, and USS MAN-TEN Brand for strength with abrasion resistance. For more information on any of these special steels, write United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

USS, "T-1", COR-TEN, MAN-TEN and TRI-TEN are registered trademarks

USS

United States Steel Corporation—Pittsburgh
Columbia-Geneva Steel—San Francisco
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Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Supply—Steel Service Centers
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CORROSION-PROOF PROTECTION WITH CLEVELAND CONTAINERS

Illustrated are telescope VPI containers used by Cleveland Rock Drill plant, LeRoi Division, Westinghouse Air Brake Co., with spare parts they protect.

Are you having trouble protecting precision parts from RUST and CORROSION?

The answer may be Cleveland Containers with liners treated with VPI ... Vapor Phase Inhibitor ... which are both economical and highly effective against corrosion.

Use of VPI containers also have three *extra* money-saving advantages:

1. **Eliminate the need of heavy protective oils or greases.**
2. **Parts are clean and ready when removed from the VPI container.**
3. **No loss of the rust-preventing VPI factor when parts are removed or replaced.**

Constructed of quality fibreboard with metal ends, the 2-piece containers, shown above, are made in a wide range of diameters and lengths to "fit" a specific part or product. VPI containers can be labeled with preprinted wrappers, direct printing, or plain color wraps.

For detailed information about these containers, write our nearest plant.

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ATOMIC ENERGY

"Coated-Particle" Fuel

The Atomic Energy Commission has assigned to Battelle Memorial Institute, Columbus, Ohio, under an existing Commission contract, a task for conducting a 3-year research program on the "coated-particle nuclear fuel concept." The objective of this extensive program is to develop coated particles with high-temperature properties, fission product retention capability, and good neutron economy. This program will provide much of the fundamental information required in support of the over-all Commission effort on coated particles.

In the coated-particle process, small grains of the fissionable nuclear fuel compound—comparable in size to common table salt—are coated individually with a dense, refractory material that will both protect the fuel from damage by chemical reaction at the high temperatures of the nuclear reactor and prevent escape of the troublesome radioactive by-products formed in the fuel by the fission process.

Both carbon and alumina coatings have worked well in early tests conducted at Battelle in work related to the pebble bed reactor concept. After coating, the fuel particles are evenly dispersed, like gravel in concrete, in a material, such as graphite, which can be conveniently shaped into reactor fuel elements by mass-production methods.

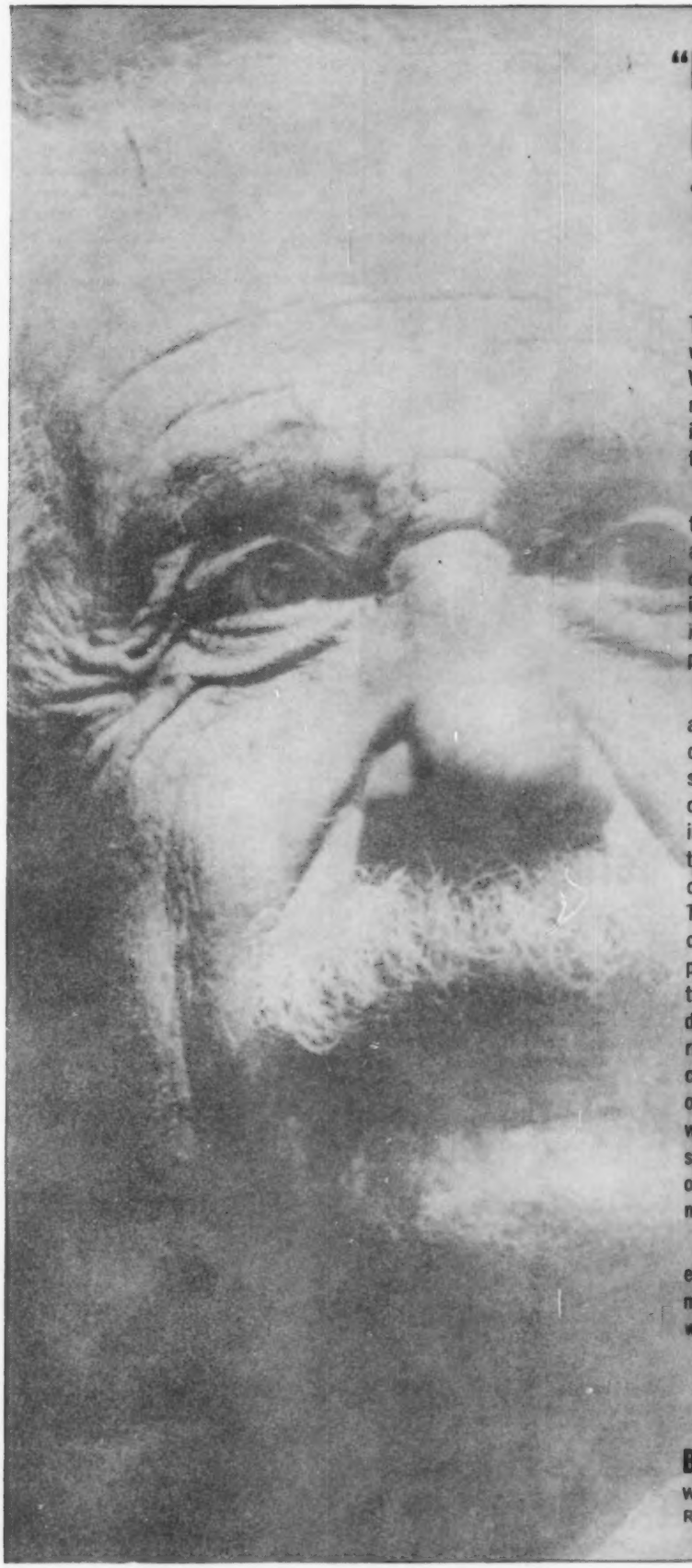
Such a fuel appears particularly attractive for high-temperature operation because only nonmetallic refractory materials are utilized. In contrast, presently used fuel elements are temperature-limited by metallic cladding. In addition, good neutron economy can be expected from coated-particle fuels.

Fast-Burst Reactor

A small research reactor to provide short bursts of radiation for biomedical and health physics research will be built at the Atomic Energy Commission's Oak Ridge National Laboratory (ORNL) in Tennessee.

The new reactor, designated Fast Burst Reactor, will consist mainly of a core of uranium-molybdenum alloy without shielding or moderator. Radiation exposure will be very small outside the limited-access area.

The Fast Burst Reactor project, estimated to cost $1,400,000, will include the reactor, a building to house the reactor and accessory equipment, a storage vault, and a separate control building. The con-



"IMAGINATION IS MORE IMPORTANT THAN KNOWLEDGE"

Albert Einstein

There are some who might argue this point with Einstein. But this much is certain: Wherever new knowledge is sought, imagination lights the way. And surely, only imagination of rare quality could have led Einstein to formulate his principle of relativity.

Einstein applied the insight of imagination to basic science. But imagination can be just as powerful in the creation and application of technology. And nowhere, perhaps, is imagination challenged over so wide a range in both science and technology as in the problems of electrical communications.

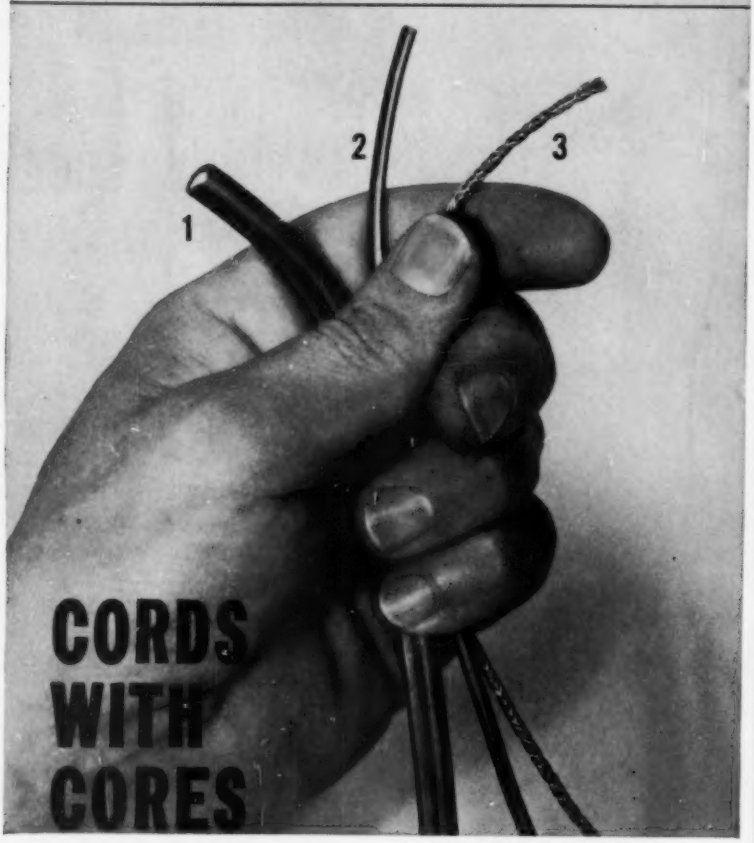
At Bell Telephone Laboratories, scientists and engineers range far and deep in search of the answers. They probed deep into solid-state physics to discover the transistor principle, and they speculated and synthesized in an entirely different area of knowledge to create the giant microwave system that carries your TV programs across the country. They study ways to protect the giant molecules in plastic cable sheath, and they explore the basic information content of speech to devise better ways to transmit it. They devise ultrasensitive amplifiers to capture radio signals from distant places, while they conceive and develop new switching systems of unprecedented capabilities. Side by side with the development of transoceanic cable systems they are exploring the possibilities of world-wide communications via man-made satellites.

By exploring every pathway to improved electrical communications, they have helped make your Bell System communications the world's best and they will work to keep it so.

BELL TELEPHONE LABORATORIES

WORLD CENTER OF COMMUNICATIONS RESEARCH AND DEVELOPMENT

Ask your **Du Pont Explosive Systems Specialist** *about:*



that detonate or deflagrate

Detonating Types

1. To cut, separate, rupture: New FLSC (Flexible Linear Shaped Charge) applies explosive force directionally through V-Channel. The V-shaped flexible metal tube containing a high explosive core provides a sharply defined cutting action when detonated. This instantaneous cutting tool is useful in destruct systems, and for a variety of applications where rupture or separation is required.

2. To convey a detonation without blast damage to adjacent areas: Du Pont MDF (Mild Detonating Fuse) can contain as low as 2 grains explosive per foot or can be jacketed with a variety of materials such as lead, aluminum, plastics, wire, textiles to give greater abrasion resistance and tensile strength or decrease the noise and adjacent damage resulting from the detonation. MDF can be initiated either by an electric or non-electric means. Use of the non-electrical system eliminates extraneous or static electricity hazards and provides a method for transmitting a non-electrical, non-destructive impulse.

Deflagrating Type

3. A versatile ignition device: Du Pont "Pyrocore," a flexible cord igniter, is a small diameter, continuous metal tubing containing a detonating-ignition core. Typical specifications are:

Outside Diameter: Range in Inches—0.051-0.105
Total Weight: Grams/Ft.—4-20
Approximate Velocity: Ft./Sec.—12,000-21,000

This fast, uniform, minimum-residue igniter can be initiated either electrically or non-electrically. Why not evaluate this versatile igniter for the solution to your design problem?

Think Explosively. The Explosive Systems Specialists at Du Pont may have the answer to your design problem. For details on these and other explosive specialties write: Du Pont, 2446 Nemours Building, Wilmington 98, Delaware.

DU PONT REG. U.S. PAT. OFF. **WEAPON SYSTEMS SPECIALTIES**

BETTER THINGS FOR BETTER LIVING... *THROUGH CHEMISTRY*

trol building will be located about 800 feet away, behind a ridge, to provide a shielded facility for remote operation of the reactor.

The reactor design provides for a pulse of forty microseconds (forty-millionths of a second) consisting of fast neutrons as free as possible of thermal (slower) neutrons. In addition, the reactor can be operated under constant steady-state conditions at power levels up to one kilowatt.

The research program with the Fast Burst Reactor at ORNL will be concerned principally with radiation dosimetry in connection with instrument development and dose determinations and radiobiology programs involving both large and small animals. In addition, the facility will be available for programs involving medical uses of ionizing radiation, solid-state physics, nuclear chemistry, and neutron physics research.

Nuclear Rocket Engine

The Atomic Energy Commission and the National Aeronautics and Space Administration Nuclear Propulsion Office recently invited proposals for research and development of a nuclear rocket engine. This selection, although based on a company's capability to carry out the entire nuclear engine development program, will result initially in a contract for the first phase only. This phase will include assistance to the Los Alamos Scientific Laboratory in the conduct of the Kiwi-B test program, and performance of certain research and development tasks on nonnuclear components.

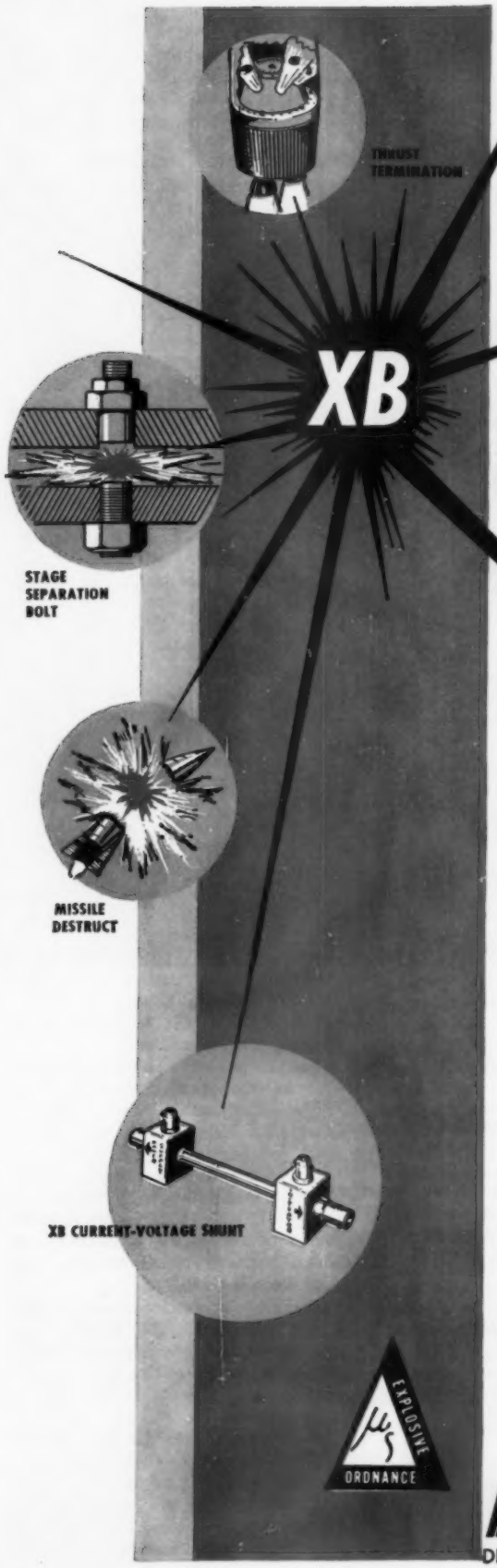
Experiments completed to date include three nuclear reactors. The last experiment, Kiwi-A3, was successfully ground-tested by its designer, the Los Alamos Scientific Laboratory, at the Nevada Test Site on October 19, 1960. This reactor used high-pressure hydrogen gas for its propellant.

Further detailed information on the engine proposal invitation may be obtained from the Contracting Officer, AEC-NASA Nuclear Propulsion Office, care of National Aeronautics and Space Administration, Washington 25, D. C. The proposals must be received by the AEC-NASA Nuclear Propulsion Office not later than April 3, 1961.

Radioactive Waste Disposal

The AEC has been conducting a project off the coast of Southern California to test the integrity of containers used to confine low-level radioactive wastes during descent to a depth of 1,000 fathoms in disposal at sea. Containers will be immersed to 1,000 fathoms (6,000 feet) and will be photographed before and during immersion.

The Commission requires that disposal

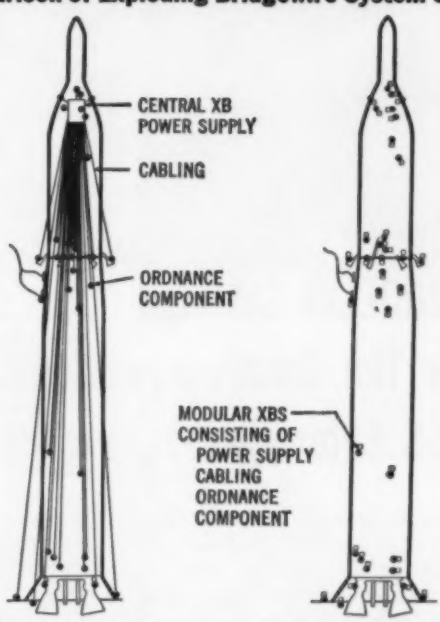


Modular Exploding Bridgewire Systems*

by McCormick Selph Associates offer:

1. Greater System Reliability
2. Simplified Cabling Problems
3. Greater Design Flexibility

Comparison of Exploding Bridgewire System Concepts


CENTRAL XB POWER SUPPLY
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Atomic Energy (Contd.)

of low-level radioactive wastes at sea be made at not less than 1,000 fathoms. These wastes include broken glassware, paper wipes, rags, and laboratory paraphernalia.

Nuclear Data Translated

The European Atomic Energy Community (Euratom), the United Kingdom Atomic Energy Authority, and the United States Atomic Energy Commission have agreed to pool their efforts to collect and disseminate information concerning translations of nuclear literature, especially from such languages unfamiliar to Western readers as Russian and Japanese. A central information office "Transatom" has therefore been established at Euratom's Brussels headquarters. It will function in two ways:

First, by publishing from December 1960 onward a monthly "Transatom Bulletin" which will list existing translations recently reported to the Brussels office, as well as new translations planned by international or national institutions and private firms in the European Community, the United States, the United Kingdom, and in other countries.

Secondly, all data relating to translations, including those made before the establishment of Transatom, are being collected and recorded in a master file system at Brussels. Copies of this card file have been offered to appropriate institutions in countries with great interest in the nuclear field.

The Bulletin is available on a subscription basis from "Transatom," c/o Euratom, 51 rue Belliard, Brussels, Belgium, at $8.00 a year, air mail $16.

Nuclear Aircraft Engine

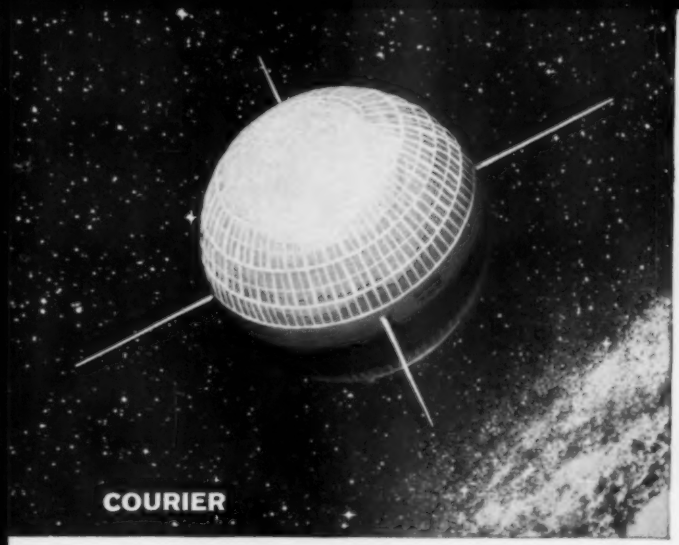
The last phase of testing for the Heat Transfer Reactor Experiment No. 3 (HTRE-3) has been completed by the Atomic Energy Commission.

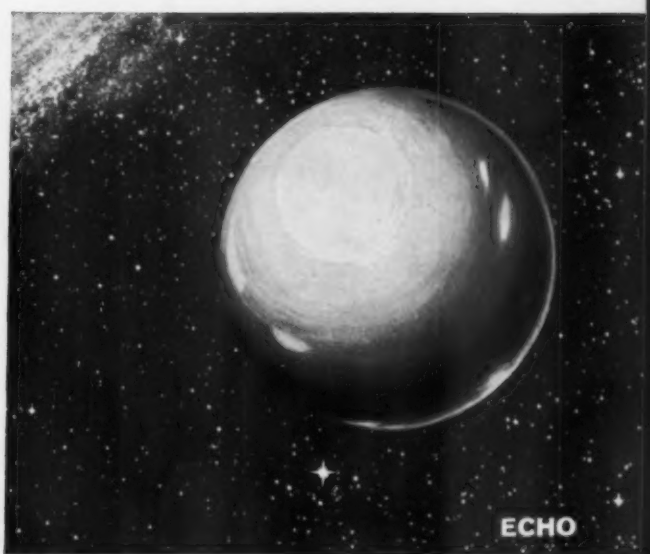
The first milestone in the HTRE program was the successful operation of the HTRE-1 in January 1956. It was the first time a turbojet engine (a modified J-47) had been operated exclusively on heat supplied from a nuclear reactor.

This first experiment was followed by the HTRE-2, the main purpose of which was to test new material proposed for use in building future aircraft nuclear propulsion power plants.

The third in a series of heat-transfer reactor experiments, the HTRE-3, was built to test higher-performance reactors. It also was the first design in a horizontal configuration as would be required for flight purposes.

In November 1960 the last phase of HTRE-3 testing began. During this phase another objective in the HTRE program was attained when two turbojet engines were started and brought up to normal operating range on nuclear power alone.





Philco Achievements in Space Technology

Philco has made many major contributions to the nation's vital space programs. COURIER, the world's first advanced communications satellite, was designed and built by Philco. Philco played a major role in the development and installation of the complex communications, command, tracking and data systems for the DISCOVERER program. Space-borne and ground communications systems for MIDAS and other satellites have been Philco designed. Philco developed and installed the tracking and receiving systems for the Air Force Passive Satellite Relay Link, which utilizes the ECHO satellite. In the field of human factors engineering, Philco has developed personnel subsystems for several major space projects. Philco also produces the world's largest 3-axis satellite tracking antennas.

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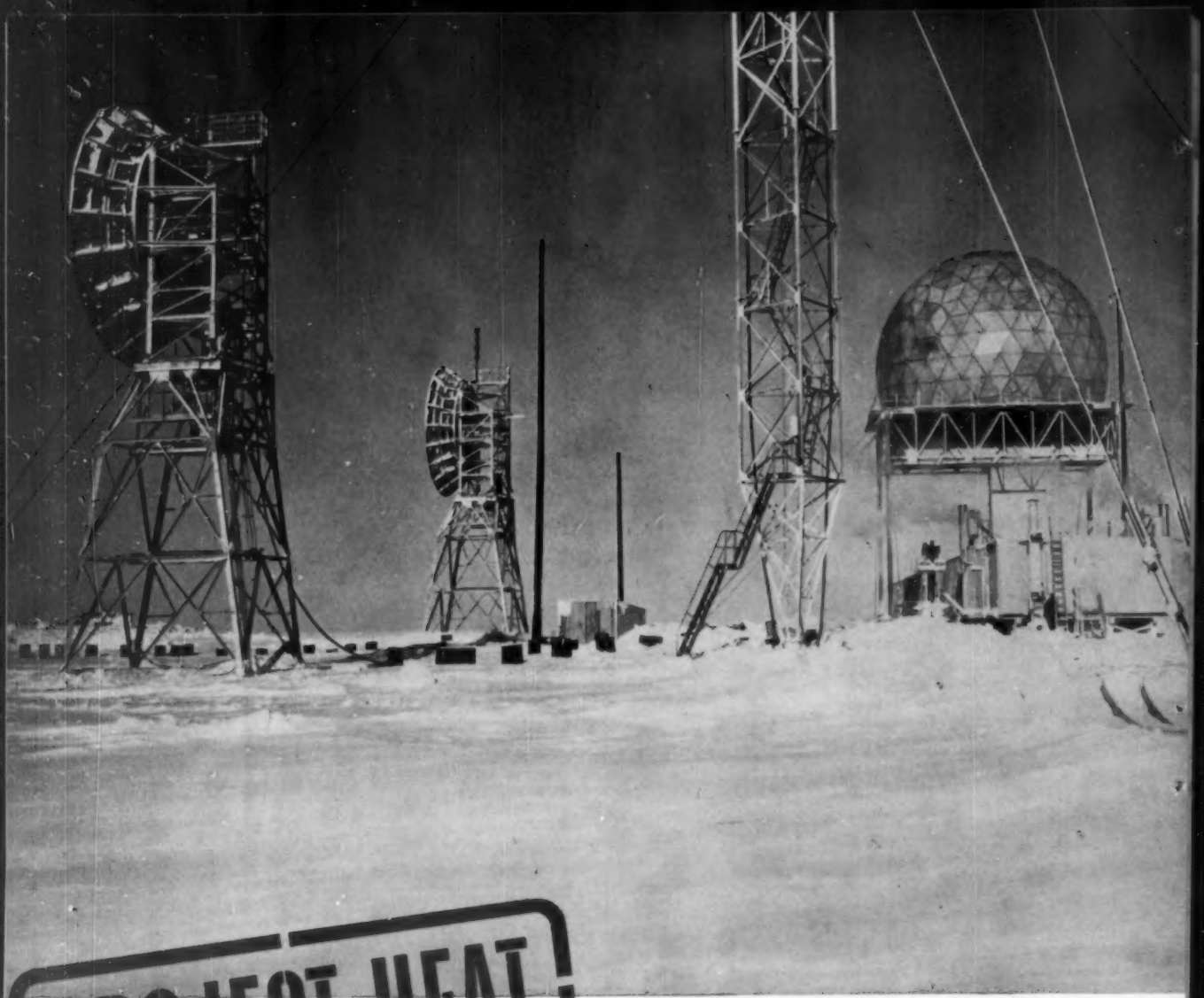

PROJECT HEAT

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vital voice for far east outposts

Okinawa-Formosa Signal Corps Communication Link Completes Pacific System Spanning 400 miles of water, the Far East Scatter System, operated by the Signal Corps, is a highly reliable link in the important Trans-Pacific Scatter System. Alpha personnel engineered the Far East system and provided all site preparation, roads, buildings, antennas . . . as well as the Collins tropospheric scatter equipment. Construction of the stations joining the significant outposts of Okinawa and Formosa took place under the severe topographic and weather conditions of the typhoon-prone Pacific. Field personnel from Alpha are now working side by side with Signal Corps technicians operating this vital multi-channel voice, teletypewriter and data communication link.

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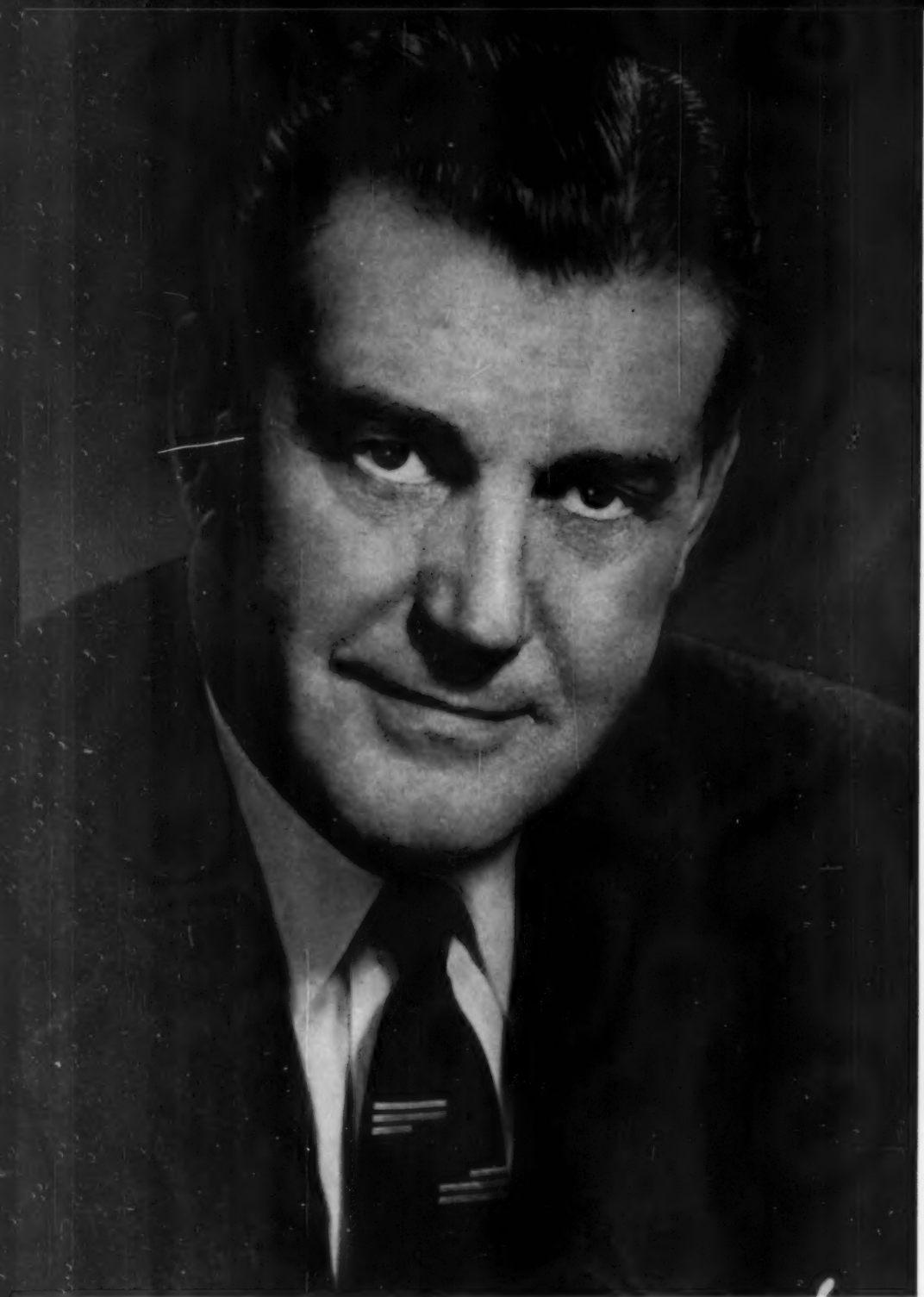


J. E. TRAINER

New president of the American Ordnance Association

Our Defense Moves Ahead

The Industry-Ordnance Team is the bulwark of national security

THE fine balance which is traditional in the United States among government, military, and private producers of arms is unique. It has its genesis in history, and the wisdom of the relationship has been proved time and time again.

To state the position succinctly is not difficult. In our economy it is the responsibility of government to make certain that research, development, and ability to produce arms are maintained at all times. One of the basic purposes of the founders of our Nation was "to provide for the common defense." The assurance of an adequate supply of effective arms is an essential of this mandate.

The pattern that has been followed in meeting this responsibility over the years is also unique. It differs from the conditions which prevail in most European countries where an arms industry, subsidized on a permanent basis by government, is relied upon to design and produce the needed weapons.

With us the reliance is placed solely upon private industry for all commercial supplies, but for noncommercial items such as weapons, government maintains a nucleus of facilities and skills and depends upon private industry for major production.

IT is traditional in our governmental framework that a nucleus of government-owned and -operated arsenals be maintained to keep the art of weaponry alive when international tensions and popular interest in defense are at such a low level that there are not sufficient funds to justify major operations by private industry.

James Edward Trainer, prominent in American industry for many years, is a senior corporate official of Firestone Tire & Rubber Company, Akron, Ohio. He is a native of New York City where he majored in electrical engineering at the Pratt Institute of Science and Technology.

After service in the Army in World War I he became general superintendent of all manufacturing plants of the Babcock & Wilcox Company where he was instrumental in the development of welding for pressure vessels.

He joined Firestone in 1939 as production manager in charge of all plants. Later he became vice-president for production and a director of the company and is now executive vice-president.

During World War II Mr. Trainer received two citations from the Chief of Ordnance of the Army for Firestone's production of ordnance. He also served on the War Production Board and led the joint industry efforts in producing synthetic rubber and other materials.

He served as a director of the A.O.A. in the days when it was the Army Ordnance Association and subsequently when it became the American Ordnance Association.

He organized and directed the Association's Artillery Division immediately following World War II and is presently chairman emeritus. When he relinquished that chairmanship he was awarded the Association's first Bronze Medallion in grateful recognition.

As successor to Louis Polk, under whose presidency the Association achieved new heights, the new president of the A.O.A. brings loyalty, talent, and energy to the administration of America's only society for the advancement of armament preparedness in the United States.

Today, with the international situation so acute, our worldwide obligations so widespread, and the assurance of survival so predominant, it is mandatory that we utilize all the powers and processes of private industry for research and production in adequate quantities of the weapons our military authorities need.

So, in the current situation, the industrial complex that is the pride of our country is also the arsenal.

AS there has been a recent change in command of our national government in conformity with the Constitution of the United States so, too, the Association, in conformity with its constitution, has inducted a new president. He is J. E. Trainer, well-known throughout American industry and a tower of strength over many years in the Ordnance cause. He takes his place in a long line of distinguished American citizens who, through the American Ordnance Association, have volunteered their services to help keep America strong.

He has had vast industrial experience as an official of Firestone Tire & Rubber Company, which itself is a sterling example of the unique pattern of armament production in the United States. A world leader in the design and production of rubber products, the company has, in time of emergency, turned part of its great production capacity to the manufacture of arms.

In World War II, Firestone was a leader in producing artillery. In the present cold war it has added its capability to the over-all production of missiles. But Firestone is essentially and predominantly a producer of products used by every American in daily life.

Mr. Trainer and the company he represents are ideal examples of the American pattern of weapons preparedness. The Ordnance Association and the Nation are fortunate that it is so.

Aerospace Power Today

Our current weapons are good, but many paths are open to greater combat capabilities, some leading to advanced aerospace armament and others to more effective means of waging land and sea warfare

Gen. Thomas D. White

THE interest and support of the American Ordnance Association in scientific and industrial military preparedness is a most important contribution to our country's total defense effort. This is especially true in today's technological race when the armed forces must depend—more than ever—upon the skills, talent, ingenuity, and cooperation of United States science, industry, and labor.

There can be no question that close partnership among all participants is a continuing requirement if this country is to possess the military strength it needs to survive as a free nation in a peaceful world.

On December 7, 1941—a day which I am certain none of us will ever forget—strong United States military forces in the Pacific were crippled by a single swift and deadly air attack. We were caught by surprise at Pearl Harbor—yet we managed to survive as a nation. But we now know, just as surely as day follows night, that we can never again be caught flat-footed—and survive.

In 1941, the Japanese war machinery started turning almost two weeks prior to their attack against us—their fleet sailed toward Hawaii on November 26th that year—with the final decision to initiate hostilities being made one week before the bombs were actually dropped. It was as if, while we were watching a football game two Saturdays ago, an enemy started to move his forces into position for an attack which was destined to take place today.

General White is Chief of Staff of the United States Air Force, Washington, D. C.

Modern weapons have introduced new elements into the formula for surprise. Instead of starting to move on the 26th of November, an enemy could—by pushing a button about half an hour ago—cause an attack upon our country at this very moment. Surprise in the year 1960 is measured in minutes—not days.

Nuclear weapons, then jet aircraft, and now ballistic missiles have necessitated a reassessment of our strategies and concepts to ensure our possession of the means to withstand a surprise attack and preferably to prevent it. In these evaluations, one thing has become abundantly clear—despite new variables, the one constant factor is still the requirement for dominant military force which can repel and decisively counter any blow against us—regardless of circumstances.

To maintain a dominant military posture requires the simultaneous performance of two difficult and costly tasks. The first of these is to maintain forces in being, equipped with the most effective weapons that the resources of this Nation can provide—forces which are constantly on alert and ready to fight on a moment's notice. This is primarily the military's job, and at this moment men in uniform in all services are standing combat alert throughout the world to preclude the consequence of a nuclear-age Pearl Harbor.

OUR second task—one which is perhaps more difficult—is the prevention of a technological Pearl Harbor. This mission is truly national in scope because it involves practically every facet of American science, industry, and labor as well as the military. It features the pursuit of new and more effective combat and support systems to ensure the continued military dominance of this Nation. In this way we will provide the greatest insurance against technological as well as military surprise in the years ahead.

Two factors complicate this second task. First is the extremely rapid rate at which modern technology is moving. Secondly, and closely associated with the first, are the increased costs inherent in the search for, and the development and procurement of, the combat and support systems we need.

Astonishing technical advances in propulsion, matériel, electronics, and communications have made possible performance considered beyond reach a few years ago. But the complexities associated with these advances have resulted in greatly increased costs—a fact

which makes the choice between weapon systems extremely critical.

Let's take a look at where we stand as of now. We have an all-jet strategic bomber force which, with the help of a growing jet tanker fleet, provides the United States with a true global strike capability—a far cry from the small B-17 force we possessed on December 7, 1941. Improved electronic countermeasures, effective positive control procedures, efficient nuclear weapons, and the advent of air-launched missiles make this force—the Strategic Air Command—the most powerful fighting force on earth. In numbers of aircraft, SAC is much smaller than it was in the days of the B-29's, the B-50's, and the B-36's. But our current force of B-47's, B-58's, and B-52's packs a better wallop.

Our fighter capabilities likewise have improved. Today, almost all of our fighters, both offensive and defensive, fly faster than the speed of sound—many of them capable of more than twice that speed. Our tactical fighters are capable of refueling in the air, giving them greater range and thus permitting their quick redeployment throughout the world in the event of emergency.

Our interceptors carry the latest in air-to-air missiles—some with nuclear warheads. Like the bombers, our fighters are fewer in number than they were a few years back, but they, too, possess greater combat potential than their predecessors.

The most astounding advances, of course, have occurred in the missile field. The greatest marshaling of men, money, materials, and scientific endeavor in American history—dwarfing even the resources assembled for the Manhattan Project in World War II—has gone into the Air Force's development of four ballistic missile systems: the intercontinental Atlas, Titan, and Minuteman, and the intermediate range Thor, and the results have been outstanding.

I THINK it is interesting to note that the larger proportion of the national investment and effort in these ballistic-missile programs is not in the missiles themselves but in what we refer to as the "ground environment"—the construction of underground silos and their hardening as well as the complex net of maintenance and test equipment which supports these missiles.

Some idea of the vastness of the construction job—which is being done for the Air Force by the Army Corps of Engineers—can be gained from estimates that our currently approved ballistic-missile programs will use enough structural steel to build 26 Empire State Buildings; enough concrete to build 7 Pentagons; enough air conditioning for 29,000 six-room houses; enough paving material for 400 miles of 2-lane highways; and enough power to light up a city of 250,000 people.

Complementing our aircraft and ballistic-missile efforts is the Air Force's quest for the capability to conduct sustained operations at extreme altitudes above the earth's surface. In this respect we now are engaged in five major projects. Two of these are manned-vehicle projects—the other three are unmanned satellites.

The X-15 and the Dyna-Soar are the initial efforts to place man at speeds and altitudes never before achieved. Of equal importance, they are our first attempts to place him in this medium with the ability to maneuver—a most important element in the manned aerospace operations of the future.

Of the three unmanned satellite systems to which I referred, two—Midas and Samos—are particularly valuable as far as defense is concerned as their main purpose is to provide us with warning of an impending attack. Midas, for example, will contain infrared detection devices designed to obtain the earliest possible warning of an ICBM attack against this country.

BMEWS, a ground-based ballistic missile warning system—one segment of which is now in operation—should give us an average of fifteen minutes' warning of approaching missiles. Midas, however, will detect missiles just after launch—while in the boost phase—thus providing maximum warning. The two systems will complement each other and provide greater assurance of longer, more reliable missile warning.

The third unmanned system—the Discoverer satellite—is primarily designed to furnish us with advanced engineering data for Midas and Samos and to develop biomedical recovery techniques—pointed to our eventual goal of man in space. Recent successful recoveries of capsules released by orbiting Discoverer satellites are good examples of the exceptional progress we are making in this program.

In our search for more effective combat and support systems, the Air Force naturally must be concerned with uncovering and solving the myriad of infinitely complex problems which comprise aerospace technology. And it is on this front that we are fighting a truly "hot" war today.

THE activities of one of our Nation's most important aerospace research installations—the Air Force's Arnold Engineering Development Center—are typical of the urgency and scope of our efforts in this area. This contractor-managed center operates high-altitude rocket test cells and high-Mach tunnels with capabilities unmatched any place in the free world. Its environmental laboratories offer us priceless assistance in developing present and future areospace systems.

In addition, the Arnold Center has ultrahigh-altitude test cells which can fire solid- and liquid-propellant rockets having thrusts as high as 200,000 pounds under conditions simulating altitudes up through the critical zone of 130,000 feet where the vacuum is equivalent to 98.9 per cent of that of space.

The center also has supersonic and hypersonic tunnels in operation which test large or full-scale models under extreme conditions of simulated flight. For example, Atlas and Titan nose-cone reentry data were obtained in these facilities. Without the advanced equipment found at this center, many phenomena of reentry and high-altitude, high-velocity flight would have remained undetected until actual flight tests had been attempted.

As a result, the development costs of Atlas, Titan, Minuteman, the B-70,

Agena B, and Discoverer—as well as other national programs such as Polaris, Saturn, and Mercury—are being reduced in terms of money and time.

We are proud that the center is presently supporting, or scheduled to support, major components of every top-priority project of the Air Force, Army, Navy, and NASA in which aerodynamic factors apply.

A great part of the effort at the Arnold Center and elsewhere in and out of the Air Force is devoted to the problems involved in manned aerospace operations. Here the question is sometimes raised as to why such research is necessary. Critics point out that we already have missiles which attain speeds of 16,000 miles an hour and altitudes hundreds of miles above the earth—and in addition to this we have various types of satellites under development which will have effective payloads in terms of warning equipment, communications, and so on.

My answer is quite simple: We must strive to conquer any so-called barriers to progress in manned flight, not because it is a challenge but primarily because the key to the security of this Nation lies in aerospace and because manned vehicles will be needed to fulfill the total requirements for the combat aerospace force structure needed to guarantee this security.

IF we need any further verification of this, we have only to look to the East—beyond the Iron Curtain—and witness the tremendous effort being devoted within Soviet Russia to placing man in space.

Thus the Air Force is working on improved manned vehicles such as the X-15 and the B-70 at the same time that we develop more sophisticated ballistic missiles and study the application of satellites to military operations.

The all-steel X-15, which has already made many successful test flights—several with its new and powerful variable-thrust rocket engine—is designed to achieve altitudes of over 50 miles above the earth and speeds of more than 3,600 miles an hour. This research vehicle will furnish many valuable data for further development of advanced aerospace vehicles.

The B-70, on the other hand, is a Mach 3 bomber designed to achieve altitudes on the order of 70,000 feet and ranges exceeding those of our present B-52's. In addition, we are working on airborne nuclear propulsion which, when perfected, will give us an aircraft of unmatched endurance.

While I am on the subject of future aircraft, I would like to turn for a moment to the question of the development of a supersonic aircraft for commercial use—because some misunderstanding apparently exists on the position of the Air Force in this matter.

The Air Force has a very lively interest in a national program to develop a supersonic transport. In the first place, only through such a program can the United States maintain its overall leadership in aviation—a leadership which is mandatory if the Air Force is to continue to be preeminent in aerospace power.

Secondly, although we cannot at this time justify the funding of a supersonic transport program on military grounds alone, we can see several interesting military applications for such an aircraft, and we would certainly make good use of it if it were made available through a national program.

It has long been our conviction that the development of a Mach 3 bomber such as the B-70 would open the door to higher speeds and performance by the civil aircraft of the future. This, however, should not be construed to mean that the Air Force feels that a national supersonic transport must be a derivative of the B-70, but there is no doubt that the experience and knowledge gained in the B-70 program will reduce the total cost and effort of the supersonic commercial transport development program.

Furthermore, unless the aircraft which is first developed under this program takes full advantage of the advanced technology of the B-70 in terms of speed and growth potential, it cannot, in my opinion, remain commercially competitive for very long. I feel that an economic Mach 3 transport is inevitable—whether this country or some other develops it.

It does not, however, necessarily follow—and I want to make it very clear that we in the Air Force do not contend—that the first of these commercial aircraft must be a modified B-70.

ON the other hand, the Air Force has been working for some time with the Federal Aviation Agency and the National Aeronautics and Space Administration toward the formulation of a national program in the commercial supersonic air transport field. Should such a program be initiated, the Air Force stands ready, if called upon, to make available its existing capabilities and to contribute to this program in the area of development management or any other way it can.

The X-15, the B-70, the supersonic transport, missiles, satellites, and probes toward other planets—all of these are additional rungs in the ladder reaching ever upward in the sky. Nevertheless, our current ventures into this vast expanse are as meager as Columbus' first boat ride compared with his eventual discovery of a new world.

Like that boat ride, however, our current efforts have opened a fascinating new challenge to further discovery and exploitation of the unknown. The difference lies in the fact that keeping pace with the challenge is a growing threat. As a result, pushing our capabilities skyward is more than a challenge—it is an absolute requirement for national security.

Many paths are open to improved combat capabilities—some leading to advanced aerospace weapons, others leading to more effective means of waging land and sea warfare. However, it is in the exploitation of advanced aerospace technology that we find our horizons truly unlimited.

It is my deep conviction that if we continue to take advantage of the opportunities existing in the boundless operational arena above the earth's surface, aerospace power's current role as a formidable deterrent to war could well be broadened to serve as the guardian of a permanent peace.

This is the end objective to which the Air Force is dedicated—and one to which I am sure the American Ordnance Association will contribute.

Making Nuclear Weapons

A high order of quality control is necessary in the production of atomic armament and since these expensive weapons may be difficult to place on target it is essential that they operate without fail

R. W. Henderson

THE production of nuclear weapons and their supporting test and handling equipment did not get under way on a significant scale in this country until late 1947. The year or so preceding that time we spent in collecting, inspecting, and assembling into usable bombs piece parts that had been left over at the close of World War II.

Those early bombs were relatively unsophisticated and were largely the product of model-shop and job-shop manufacturing methods. Heavy reliance was placed upon the individual skill of the man in the shop and upon a painstaking one hundred per cent inspection system hopefully to weed out unsatisfactory products.

WHILE this procedure was quite adequate for the needs of World War II, it was hopelessly outmoded in early 1948 by the rapidly developing requirements of the armed forces—requirements which were being paced primarily by the abilities of physicists to develop new nuclear explosive assemblies of varying power, weight, and size.

However, improved calculational techniques trimmed by the results of past experiments and proof tests of new designs pushed forward the art of nuclear explosive design very rapidly.

Although the nuclear explosive is the true weapon payload, there is necessarily associated with it a fair amount of what we call "ordnance hardware"

Mr. Henderson is vice-president in charge of weapons programs, Sandia Corporation, Albuquerque, N. Mex.

—arming and fuzing systems, supporting structures, ballistic cases, and handling and test equipment. Componentry of this type used in World War II was adapted largely from known technology with many parts simply being modified to meet a special requirement in the nuclear bomb. Where reliabiilty fell short of desired goals, compensation was achieved through redundant design.

This situation demanded and received a complete revamping both in the basic design approach and the production methods to be used. Components began to appear that were specifically developed for use in nuclear weapons, built to standards of perfection considerably beyond those found in normal industry.

The result has been greater reliability, enhanced safety, longer unattended stockpile life, and outstanding progress toward the goal of field-use simplicity normally associated with general-purpose ammunition; namely, no checkout necessary in the mission-launch procedure.

Despite the fact that in the production business it is human nature to think that the other fellow has a softer time than you do, there is one prime feature of the nuclear ordnance production activity that is rather unique and demanding of the unusual approach it receives. Nuclear weapons are built in fair quantity with the sincere hope that they will never be used—but if they are, they must work the first time, not after the second or the third try, but the first.

COMPONENTS must work the first time they are asked to after having lain in dead storage for years. There is not time to dust off the weapons, wring out the system, and exercise the complete assembly just prior to delivery to the target.

Similarly, there is little feedback of the customer complaints so valuable in any other production system I can think of. True enough, nuclear weapons are maneuvered by the military services, but this type of use is limited to logistic and procedural matters.

The proof of the weapon—namely, will it explode when and only when asked to—lies in the workings of an extremely rigid production quality control program, followed by a statistical stockpile sampling program in effect throughout the life of the weapon.

Quality cannot be *inspected* into a product at the end of the line; it must be *built* in at every step in the production process. Each piece part, process, and raw material must be rigorously

controlled if a high rate of yield of reliable product is to be achieved.

It isn't enough to know that a run of parts is within tolerance—one must know what the average is, what the range is, and if there is a systematic drift in the inspection data. Only this type of information will give warning of an impending out-of-control situation in time to take corrective action before the line starts to produce scrap. This approach is absolutely essential in the manufacture of explosively actuated one-shot components that cannot be tested without destroying them.

TO achieve this degree of control is hard enough if you own and operate your own factory, but the piece parts of the Nation's nuclear weapon stockpile are built by hundreds of suppliers spread over the entire country. Coordinating their activities and approach to the problem is understandably a full-time job for a group of specialists.

First, to achieve high quality one must be careful in the selection of suppliers. This demands that supplier surveys of a very searching character be carried out as a preliminary to deciding whether a specific company should be given an opportunity to quote on a job.

If this hurdle is crossed, the prospective supplier must next understand thoroughly how much effort he will be expected to apply in the quality-control and inspection area at each important point in the production process—and this is often quite a revelation to him. He must understand the meaning of certified raw materials and certified test results. He also must develop an estimate of anticipated rejection rate and possible rework requirements.

Only when all these factors have been thoroughly talked out is he in a position to submit an informed quotation, and we, for our part, are sure that quotations received will be truly comparable.

With the selection of the supplier, the next step begins—the evaluation of the design to be built, design tolerances, and specifications. This is the process of determining what limits the tooling and operators are capable of meeting on a production basis. It's one thing to build a few good prototypes in a model-shop—it's quite another to build the item in production quantity with acceptable yields. Low yield, more often than not, stems from design deficiencies. The production shakedown or pilot run is therefore used to adjust drawing and specification requirements while simultaneously building up the capability of the supplier to produce quality product controlled at every step along the way.

This merging of the designer's desires with the capabilities of the supplier's facility is accomplished through the efforts of a quality-control team comprised of representatives of the design and manufacturing engineering groups and their counterparts in the supplier's organization. Collectively they establish a detailed statistical quality-control program and help the supplier get it into effective operation. From there on out, it's a continuing job of monitoring results and introducing changes when the need arises.

Changes are the normal way of life in the nuclear-weapon business. Production quantities are not large as compared with what we normally think of as mass production in this country, but quality is paramount. In addition, the military services and the AEC's designers are continually pushing to get the latest improvements into the weapon stockpile.

As a result, there is no such thing as a 1960 model. Not only is change a continuous process in current production, but the Department of Defense frequently pushes the updating of older designs in the stockpile to introduce new capabilities.

REMEMBERING again that each and every weapon in this ever-changing stockpile is expected to work the first time it is asked, it is imperative that we know part by part what's in each weapon by serial number and lot number in order that we can correlate production inspection data with similar information gathered through the subsequent stockpile surveillance or sampling program. Changes or drifts in these data from initial production to retirement are the clues we use in predicting necessary maintenance or replacement of parts prior to the time the situation is out of control and the weapon is deadlined.

This is accomplished through the use of electronic data processing equipment which enables us to know very rapidly in what weapons, serial number by serial number, we installed what major components, serial number by serial number, and other parts from specific manufacturing lots of nonserialed items.

When trouble develops, it is through this system of tape records, combined with equally specific machine-handled data as to exactly where each weapon is located, that we can evaluate the problem and plan for corrective action.

As mentioned earlier, nuclear weapons make use of many explosively actuated one-shot components to perform various functions in the arming and fuzing systems. Since to test them is to destroy them, confidence in the product can only be established by firing a statistically significant sample quantity selected at random from each production lot, the size of the lot also being chosen on the basis of statistical quality control theory.

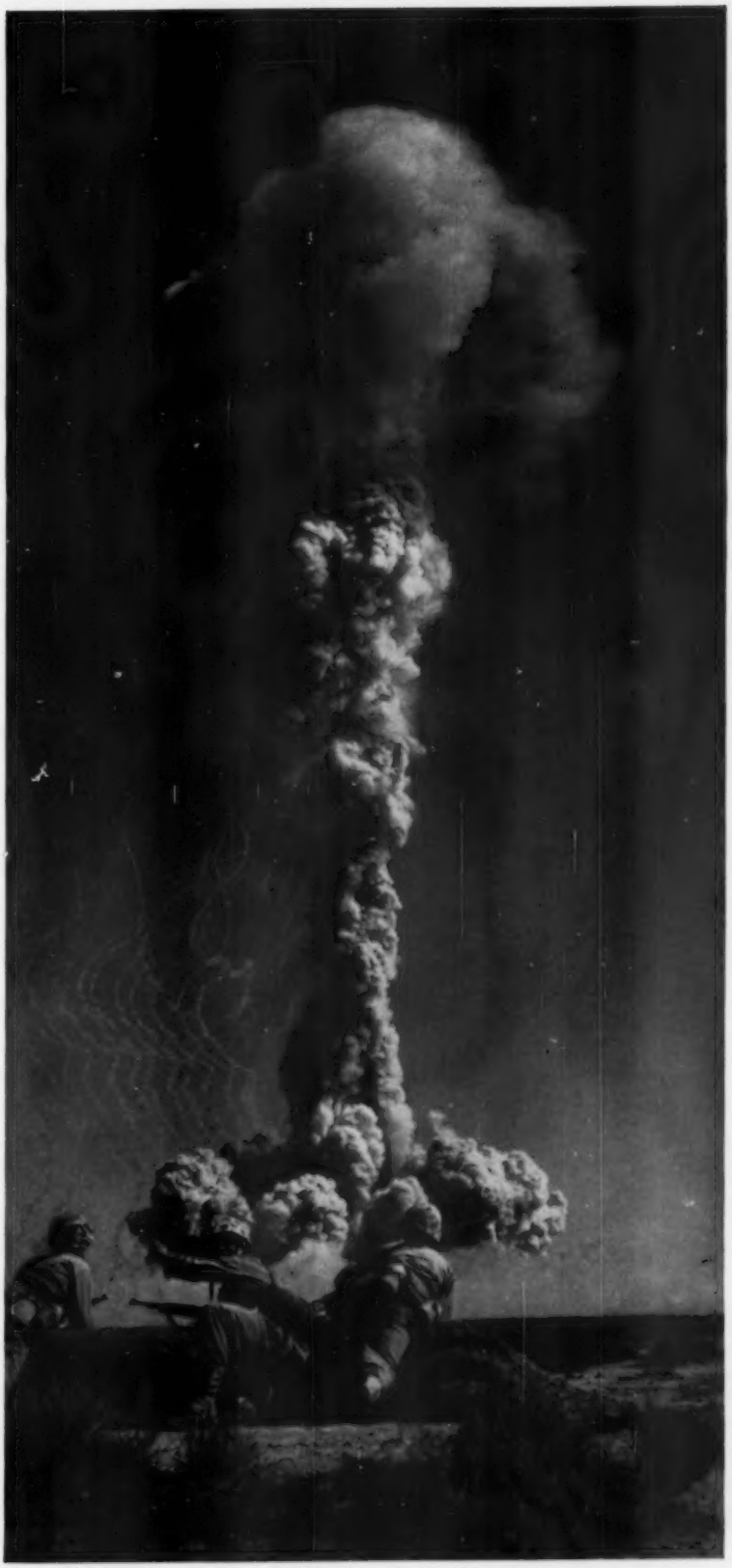
THE results of these test-firings, which may be more than half the lot in an initial production run, dictate the disposition of the remainder of the lot.

As proof of the value of this degree of control, I would like to cite the example of one such explosive switching device: This item had been in production for 32 months during which time 135,000 had been built. Of this total production, 15,000 had been test-fired with one failure, establishing an overall reliability of 0.9997 with 90 per cent confidence.

At that point in the production run 5 failures out of a sample of 652 taken from a lot of 1,450 were observed. In each failure the small piston in the device which was supposed to transfer from one end of the cylinder to the other had failed to make the full journey. Snap judgment pointed to defective powder, particularly since the powder lot had been changed just prior to the observed failures.

However, before launching into a

"Each and every weapon in this ever-changing nuclear stockpile is expected to work the first time it is asked" (Marine Corps photo).



time-consuming and costly witch hunt in the powder-manufacturing process, all production data on the mechanical parts of the device were studied, bring-out the fact that a 2-step reamer having two cutting edges had been changed on this lot to one having four edges.

Going back to the two reamers in question, which were identifiable, it was observed that the method of forming the cutting edges produced a minute radius at the transition between the steps in the first reamer that was missing in the second. It also was determined that the 4-flute tool, run at the same speed as the 2-flute tool, resulted in work-hardening of the bore.

These extremely slight differences in the resulting cylinder bore caused the piston travel malfunction. A return was made to the original reamer design and the problem quickly solved.

Statistical quality control and its attendant records of each important detail in the production process saved tens of thousands of dollars in locating and correcting this production snag—to say nothing of the assured reliability it builds into the Nation's nuclear weapon stockpile.

Characteristics of components or materials also may change with time, and meaningful analysis of these trends demands selection of a statistically significant number of weapons of a given type by serial number selected at random at specific intervals over the expected stockpile life of the weapon. These selected weapons are then subjected to simulated missions intended to expose them to all the important environments they were designed to meet.

Nuclear weapons are not cheap, and I have outlined a few of the reasons. We are therefore sometimes asked why we strive for reliabilities markedly higher than can be expected of the delivery systems that have to put them on target. The answer is simple: penetration to the target may be very difficult; therefore the bomb or warhead that does get there had darn well better explode!

Production and Policy

For the most economical manufacture of military equipment by our free enterprise system it is necessary that competition, the prospect of profit, and the risk of loss become elements in defense contracts

Russell A. Crist

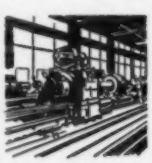
Mr. Crist is former director of the Office for Production Policy, Office, Assistant Secretary of Defense (Supply and Logistics), Washington, D. C.

WE are now turning to a new chapter of history as a new national Administration takes office. This is a particularly appropriate time to look to the future as well as to the past, and to use the experience of the past in charting our future course.

It is a time for quiet thought and objective evaluation of our progress and status as a nation, and particularly of our defense posture. The core of that posture is production capability and readiness to respond to any emergency.

Let me review somewhat in capsule form the nature of production policy and its source in Government. And then proceed to some problems that I feel are appropriate for discussion at this time.

Possibly the most salient comment that can be made regarding Department of Defense policy is that the Department is not an authority unto itself. While it is true that the Department of Defense publishes numerous policies of critical importance to industry, these policies necessarily are framed within the context of legislation passed by the Congress and in compatibility with general policies issued by various agencies of the Executive Branch of the Government.



As regards legislation, in 1950 Congress passed the Defense Production Act. This act is of historical importance from a production point of view as it grants the President extraordinary peacetime power in maintaining the productive capability of the Nation in a postion of readiness.

There are three other basic pieces of legislation which are the statutory authority for the planning and implementation of the necessary measures to place the Nation in a current state of readiness: (1) the Strategic and Critical Materials Act of 1946, (2) the National Security Act of 1947, and (3) the Renegotiation Act of 1951.

Besides legislative considerations, Department of Defense policies also must be formulated within the framework of national security policies as established by or under the authority of the President. Matters of national security policy come to the Department of Defense in the form of decisions of the National Security Council, as Executive Orders, or as issuances of the Office of Civil and Defense Mobilization (OCDM).

Additionally, the Department of Defense is subject to administrative policies promulgated by the Bureau of the Budget.

Subject to these basic mandates, the Department of Defense publishes policies, in the form of directives, applicable to the military departments. Within the Office of the Assistant Secretary of Defense (Supply and Logistics), there are various offices responsible for policy and the administration of different facets of supply and logistics. There is an Office for Procurement Policy, another Office for Supply Management Policy, one for Planning and Requirements, etc. There is likewise an Office for Production Policy.

IN the light of what I have said and in view of the broad spectrum of activity that constitutes production, it goes without saying that this office is not charged with total responsibility for all aspects of production policy.

There are, however, specific areas of production for which the Office for Production Policy is responsible, namely: (1) military urgencies, priorities and allocations, (2) production schedules and special assistance, (3) industrial readiness planning and the production base, (4) industrial defense—physical security program, (5) control and management of industrial production equipment, (6) Government competition with private business, and (7) inspection, quality control, and reliability.

In general, then, the term "production policy" in the abstract refers to all those laws, rules, and regulations laid down by the Congress and by various elements of the Government, in-

cluding the Department of Defense, to guide and govern the military departments in developing and assuring adequate capability for the fabrication of supplies, equipment, and weapons, now and in the future. The Office for Production Policy of the Office of the Assistant Secretary of Defense (Supply and Logistics) is responsible for particular aspects of production policy but not for total production policy.

This, then, is a broad-brush treatment of the nature of production policy, its source in legislation and regulations.

Let us now consider problems related to production but not necessarily circumscribed by the nature of production *per se*.

For purposes of orderly discussion we might divide these problems into two classes, primary and secondary. The term "primary" is self-explanatory. By "secondary" I mean procedural, operational, or similar matters that, in themselves, are of great importance but, nonetheless, are effects of deeper causal situations.

LET me mention a few of the problems I choose to identify as "secondary." The first and foremost is the challenge to produce reliable—and I repeat, reliable—equipment at reasonable cost. This is a subject we could discuss from various points of view. I will return to it later because it is related to what I consider a more fundamental problem, a *primary* problem.

Secondly, on the plant level we face the problem of concurrent production and research, more frequently called "telescoped" production.

Thirdly, there is a question of rational and equitable distribution of production facilities to support the national economy.

Fourthly, there are differences of opinion regarding the rights of Government and industry respectively in the area of technical data.

Fifthly, we face difficult questions with regard to industrial readiness planning. To what extent should we maintain a stand-by capability in production in the light of galloping progress in production technology and weapons improvement?

These issues, despite their significance, are of secondary importance to the more transcendent question of the role of private enterprise in national defense.

The subject of the role of private enterprise in national defense is a difficult one. However, after forty years in industry and after three years in the Department of Defense I am inclined to think that I am in a favorable vantage point to look over the industrial-military situation and comment on the climate in which most of us in this field live. On the other hand, I do not imagine myself on a summit with a 360-degree perspective of the total situation.

Let me then proceed to the primary problem. There are perceptible undercurrents, rumblings loud enough to be heard, loud enough to cause all of us to pause for a moment and ask whether or not the American free-enterprise system is properly geared to serve the national interest as well as itself. These rumblings are sometimes faint and sometimes quite strident.

Some of these undertones take the form of opinions expressed casually, in the course of day-to-day meetings, in correspondence, in lectures and briefings, in all the various ways by which we sense or think we sense trends in public opinion.

On the literary scene many writers are speaking their piece along lines that are ominous, that indicate restiveness with the economic structure generally and with defense economics specifically. There are other symptoms.

For example, on the "dollar-and-cents" level, the level that the businessman particularly understands, there is apprehensiveness in the Department of Defense regarding the cost of military equipment. There is widespread feeling that industry could cut these costs if it really put its shoulder to the wheel.

"There is need to meet a fundamental issue head-on. This issue is whether industry is presently oriented and geared, fully and effectively, to exploit its own inner dynamism and thus serve better the national interest as well as itself."

There is another school of opinion that takes the view that in some vicarious way industry indulges in considerable waste, produces material of less than satisfactory quality and reliability, indulges in vast numbers of contract changes of questionable validity—all to perpetuate itself. The subject of "made work" in defense is quite analogous to the more popular discussion about "planned obsolescene" as an artificial prop of our national economy.

This uneasiness that I am talking about is articulated in many different ways, sometimes highly philosophical, sometimes highly practical and factual.

Many observers who classify themselves as practical men par excellence are becoming alarmed at the rising cost of maintenance. There is substantial information available showing that maintenance costs in the Department of Defense are rising so steeply that there is good reason to be concerned about the future. It would seem that these costs stem, among other causes, from less than satisfactory quality and reliability.

Shortly before I prepared this paper I was leafing through the proceedings of an unclassified conference conducted by the Bureau of Naval Weapons on the subject, "Reliability with Economy —A Challenge." I was struck by the types of things—reliability and maintenance and costs—that are giving military people great concern. The conferees seemed to be saying that these rising costs can be controlled without sacrifice of quality or quantity of production.

It would not be very difficult to go on like this and mention a substantial body of evidence that spells disquiet, that suggests that industry might not be serving defense as effectively as it could.

Again for the moment I should not like to take sides. I am simply reporting some fragments of opinion as I hear them.

But the mere fact that such opinion exists should cause businessmen, par-

ticularly industrial executives, to sit up and take notice and render an objective judgment of its validity. If such opinion has any validity it goes without saying that corrective action is in order.

May I, however, for the moment, solicit your good will and assume for purposes of discussion that this disquiet is not fictional—that it might have some foundation in fact—that it is real enough for us to take a long second look.

If you grant me the liberty of making such a tentative assumption, I should like to pose this question: *If* our free enterprise system in its relation to defense is truly less effective than it might be, what is the cause of this alleged malaise?

May I suggest tentatively that it may well be that the free-enterprise system as you and I know it, in the defense environment, has lost to some degree, three of its most vital, dynamic, and distinctive characteristics. These are (1) competition, (2) the prospect of profit, and (3) the risk of loss.

This general point of view is well expressed in a recently published book entitled "Economics of Defense in the Nuclear Age." Let me quote:

"IT is not enough to entrust production, development, and management functions to private contractors. When goods and services are purchased by Government agencies on the basis of full and free competitive bidding, there is a presumption that competitive forces, working through the price and market mechanism, will provide the same spur to efficiency and low-cost supply that they do elsewhere in the private economy.

"But only a rather minor portion of service purchases are made, or can be made, on the basis of competitive bidding. The expensive items of major equipment like aircraft, submarines, tanks, and their expensive major components can be produced by very few companies, and their production costs are seldom accurately estimated in advance. Moreover, frequent modifications of the original design are the rule rather than the exception both in development and in production."

You will concur, I'm sure, that the Department of Defense has reason to be concerned with the economics of defense. It must assure itself and the public that costs are not generated by industrial self-interest and do reflect genuine concern in improving our defense capability. It seems logical, therefore, to assume that if the price and market mechanism of the free-enterprise system is not working effectively then the system is not intrinsically capable of economic production; that is, production that gives a maximum return in usable equipment per invested dollar.

Probably then there is need for a new delineation of the Government-industry relationship and for a revival of free enterprise in its purest form. In the absence of such a reorientation-industry might well have good reason to look to its own future with some misgivings. If it should develop that industry cannot effectively and economically serve the national interest, it is inevitable that new patterns for industrial production will evolve.

I do want to reemphasize that as a matter of immediate concern we have to probe the causes of the high cost of defense. The reason for this is self-evident. Unless we control production costs, unless we control the root causes of spiraling costs, we will be hard-put financially to maintain the weapons systems we are now producing.

This is no idle talk. This is a provable fact, and this fact is generating concern. This concern is reflected, I think, in a recent regulation (375-5) published by the Air Force. It is a rather forceful regulation. One of its provisions reads as follows:

"If contract reliability requirements are not met, or if the contractors' reliability effort is decreased, the decision to accept or reject the end item or the revised reliability program will be considered with a view toward monetary penalties, unit price decreases, or other considerations deemed equitable."

There are, however, serious limitations on what Government can do to enforce a policy of this kind. Ultimately its enforcement depends on the intelligent and wholehearted cooperation of industrial executives.

But I do not want to bemoan high costs without making some positive suggestions as to what can be done.

My first suggestion is that top-level management involve itself more deeply, with heart and mind, in the whole process by which components and systems are described, produced, and tested.

Management in both Government and industry must exert itself to assure that contractual understandings define clearly, and in forthright, explicit, technical, and mathematical language, what the consumer expects and what the producer is expected to deliver in terms of performance, particularly life expectancy. This alone could have the effect of improving the military-industrial climate.

TO illustrate my point, my attention was recently called to a contract that had been redrafted. The original contract said that the contractor is responsible for delivery of a product of "satisfactory performance." It further said that "satisfactory performance" shall include the "highest practical reliability level attainable."

Obviously this was a hopeful and somewhat pious statement. The reliability requirement was vague. The contract lacked quantitative performance requirements. It did not include any indication of how a determination was to be made that the contractor delivered "the highest practical reliability level attainable."

The redraft of this contract has a specific requirement that the equipment operate with a "mean time between failures" of a prescribed number of hours. It also provided that the testing procedures incorporate a ninety-five per cent probability that the "mean time between failures" equals or exceeds a specified number of hours.

This is an oversimplification of the terms of the contract, but it illustrates what I mean by being "explicit." This puts the burden on the producer to give the consumer what he really wants. While such explicit contracting cannot always be done, it often is possible.

"Many observers who classify themselves as practical men par excellence are becoming alarmed at the rising cost of maintenance. There is substantial information available showing that maintenance costs in the Department of Defense are rising so steeply that there is good reason to be concerned about the future. It would seem that these costs stem, among other causes, from less than satisfactory quality and reliability."

I should like to recommend also that management take a penetrating look at production engineering and testing operations to determine whether proper provision is made to review designs for accuracy and adequacy and whether expenditures for testing and testing facilities are really essential and truly pertinent to contractural requirements. These are two areas which are contributing substantially to spiraling costs. There is good reason for saying that much of our cost stems from the "fly and fix" concept rather than from sober and concentrated attention to detail.

Management also might control more firmly the total process of design and redesign. There is reason to suggest that repeated redesign and retesting are exploited to serve the interest of perpetuating bureaucracy and for generating "made work" in industry.

OVER the years we have heard and read many times statements like these:

"No other country in the world has the industrial strength of the United States."

"No other nation is better equipped to supply the products needed for its defense and at the same time meet its economic needs."

To these statements I give my strong assent.

The fact remains, however, that we are not living in a period of a frozen status quo. Conditions are subject to change, if they are not already in the process of change.

If we are to preserve our industrial and economic strength, improve our defense posture, and build the security we must have, there must be a realistic confrontation of the problem we face; namely, that we cannot continue to build security unless the spiraling costs of military equipment are restrained.

Both of our political parties are committed to building the security we must have. But both are also resolved to do this without compromising our basic economic strength. To do otherwise would be to play into the hands of the Communist bloc.

I repeat, then, that there is a need to meet a fundamental issue head-on. This issue is whether industry is presently oriented and geared, fully and effectively, to exploit its own inner dynamism and thus serve better the national interest as well as itself.

Before I conclude I should like to repeat, as I have mentioned earlier, that I am attempting to discuss a difficult problem and I solicit your earnest study of this problem. I have suggested a few more or less short-term measures to alleviate the situation which, for purposes of this talk, I presume exists. I am not satisfied, however, that my suggestions are commensurate in effectiveness and in depth of analysis with the problem I am discussing at this time.

This is a problem worthy of purposeful study by all of us. It is essential that the strength and weakness of American enterprise be viewed and evaluated in broad perspective—the perspective of the national interest.

In saying this, I hope I am not indulging in platitude or preaching. Rather I am suggesting that the vast resources of American industry, as represented by the members of the American Ordnance Association, be brought to bear on this subject.

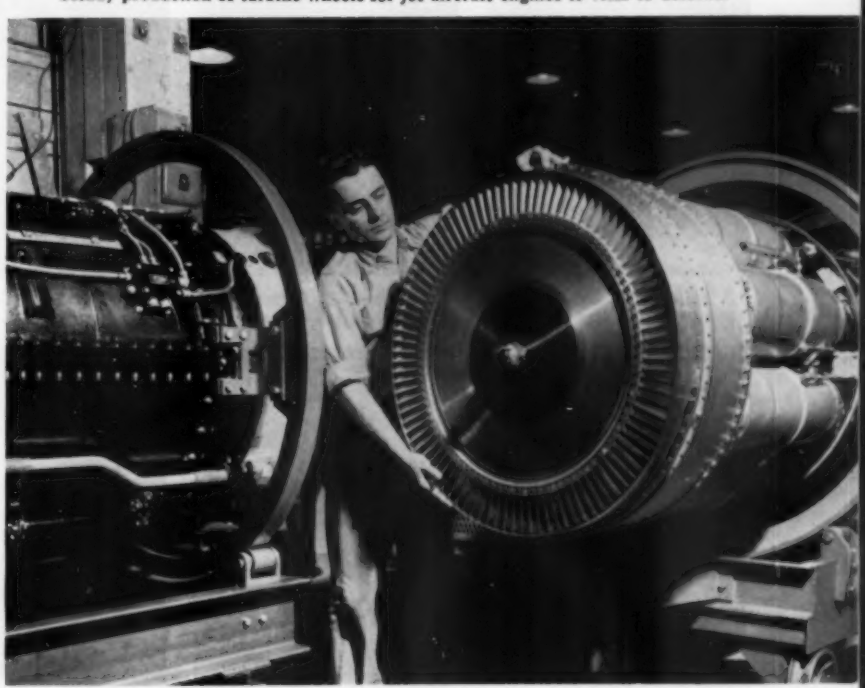
IT may well be that American enterprise is healthy and vibrant. It may well be that those who think otherwise are chronic hypochondriacs.

On the other hand, it might also be that American enterprise is not all that it should be—that it needs new vitality and a new orientation.

Whatever the facts, let's put them on the table. Let's assure ourselves that we are prepared to compete industrially and economically with the Kremlin.

But if we are less prepared than we should be—if things need to be done to make American enterprise more effective, let's waste no time in taking on the job that needs doing.

Steady production of turbine wheels for jet aircraft engines is vital to defense.



Officers and Directors of the

J. E. Trainer, executive vice-president, Firestone Tire & Rubber Company, Akron, Ohio, was elected president of the American Ordnance Association for a term of two years beginning January 1, 1961. The election was held at the annual meeting of the A.O.A. Board of Directors in New York City, December 6, 1960. Mr. Trainer succeeds Louis Polk, who held the office with distinction since 1959. Mr. Polk is president of the Sheffield Corporation, Dayton, Ohio.

These and the other national A.O.A. officers and directors, who determine and execute the policies of the Association, are shown on these pages.

J. E. Trainer
President, Akron, Ohio

Harvey C. Knowles
Vice-President, Cincinnati, Ohio

Albert G. Noble
Vice-President, Washington, D. C.

Henry N. Marsh
Vice-President, Wilmington, Del.

Leslie R. Groves
Vice-President, Stamford, Conn.

Robert L. Biggers
Director, Detroit, Mich.

Levin H. Campbell, Jr.
Director, Annapolis, Md.

Benjamin W. Chidlaw
Director, Cleveland, Ohio

W. W. Coleman
Director, Garrison, N. Y.

Paul L. Davies
Director, San Jose, Calif.

Irving A. Duffy
Director, Dearborn, Mich.

William K. Fitch
Director, Pittsburgh, Pa.

American Ordnance Association

Herbert A. Gidney
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Director and Assistant Counsel, Philadelphia, Pa.

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General Chairman, Technical Divisions and Sections, Cleveland, Ohio

James D. McIntyre
Treasurer, Montgomery, Ala.

John Ross Delafield
Counsel, New York, N. Y.

Aims and Purposes

of the

AMERICAN ORDNANCE ASSOCIATION

for 1961

¶ The American Ordnance Association, in pursuance of the objectives set forth in its constitution and by-laws, will devote its energies throughout the coming year to assist in strengthening the military and industrial power of the United States toward:

1. Complete readiness of our Army, Navy, Marine Corps, and Air Force for limited war.

2. Complete readiness of our Army, Navy, Marine Corps, and Air Force as a deterrent for unlimited war.

3. Complete readiness of our Army, Navy, Marine Corps, and Air Force for continental defense.

4. The immediate resumption by the U. S. Atomic Energy Commission in cooperation with the Defense Establishment of nuclear tests for both small and large weapons.

Program for Preparedness

The A.O.A. rededicates itself to industrial readiness for defense

Louis Polk

President, The Sheffield Corporation, Dayton, Ohio, and Past President, American Ordnance Association

NINETEEN years ago the United States of America suffered a devastating attack. The place, Pearl Harbor; the day, December 7, 1941.

The American Ordnance Association —43,000 members strong—in its firm commitment to peace through preparedness, rededicates itself to the proposition that there must never be another Pearl Harbor, that America must never be caught unprepared again—a tempting target for attack—and that the lives lost that black day in United States history shall remain an eternal reminder that our national security must be supported by continuing and growing preparedness for defense—in facilities and in spirit—more so today than ever.

Because America and its allies do not intend to become second best, the Association calls for a 4-point program to ensure armament readiness against attacks on the free world.

IT calls, first, for stress that our major problem is not one of "catching up" but of continuing a policy of initiative with respect to research and development, a policy of reliance on our ability to analyze our true needs—and of action to meet those needs—lest failure mean disaster.

It reaffirms its policy of frank dissemination of information and education of the public as to our defense needs and our national state of preparedness—within the bounds of security and unbeclouded by other considerations.

The American Ordnance Association calls, secondly, on industry to reaffirm that, as a product of the American heritage, it recognizes its responsible role in our society. It has taken impressive steps toward that end already. It has worked closely with government to fight waste of effort, time, and material—to stretch the defense dollar. Yet it must now step up its efforts to a still-greater degree.

Self-interest alone dictates to industry an enlightened approach to its obligation to extend its research and development, to look upon its business dealings with government as a chance not merely to profit but to serve, and to fulfill that obligation willingly—lest government be forced to extend its areas of control.

The American Ordnance Association calls, thirdly, on American education to increase its growing efforts to meet the ever-changing challenges to prepare our youth not only for today but also for tomorrow. Toward that end it calls for still-greater emphasis on applied space-age science—nucleonics, advanced physics and chemistry, rocketry and outer-space studies—as well as on all other sciences and technology, not on a "special-project" basis but as an integral part of the curriculum required by our times.

It calls also, as early as at the high-school level, for stress on the progressive industrial traditions that make up the fabric of our Nation, an awareness of the inseparable relationship between our kind of economic system and the precious freedoms we must help defend, and an understanding of the important tools of leadership they will exert tomorrow.

The American Ordnance Association calls, fourthly, for the American people to understand fully the necessity to be prepared to meet any attack—be it in a local war or a nuclear conflict.

One hundred and eighty-six years ago the American Minuteman picked up his musket, left his family, and fought for freedom and liberty. Today, it is important for every American to be aware that these principles must be safeguarded against all threats, defended with pride and vigor, and preserved for our children and their children.

EVERY American should remember that luxuries are not a substitute for strength, nor self-satisfaction a match for determination. He should remember that he cannot afford to become complacent, lest he forget how to become strong—that no man can be good who is not outraged at evil.

He should be aware that his very determination to defend his freedom is his best guarantee that he will not have to do so.

In these days of lightning changes, the American Ordnance Association rededicates itself to the concept of reappraising our relative position and realistically studying and developing a determined course of action—by government in keeping faith with the people, by industry in respecting its obligations, by education in keeping pace with the space age, and by the people in preserving forever peace, liberty, and democracy in the world. This is the A.O.A. program of preparedness.

Industry and Modern Weapons—I

Production for the Army

Highlights of the papers given during the seminars on America's production of defense weapons at the Forty-second Industrial Preparedness Meeting of the Association held in New York City

Lieut. Gen. John H. Hinrichs
Chief of Ordnance, United States Army

THE Ordnance Corps' mission, oversimplified for the sake of brevity, is to arm the Army. We develop and procure the weapons, ammunition, tanks and combat vehicles, rockets, guided and ballistic missiles, and all other ordnance matériel for the Army. We also supply matériel to our sister services and to our allies overseas.

The Ordnance Corps' responsibility begins with the birth of the idea and continues as long as that weapon remains in the operational arsenal. You might call it the complete "farm-to-market" sequence because it includes design, research and development, fabrication and assembly, testing, supply, maintenance, and support of the system in the field.

We have tailored our management structure to the requirements of the weapons systems to the maximum practicable extent. . . . One approach is to award the system contract to a single industrial firm, usually a large organization, which then receives most of the funding. . . . A good example is the Nike program. . . .

A second approach utilizes the in-house capabilities of the Ordnance system—sometimes referred to by our critics as the "arsenal system." In this case we carry the weapon from initial concept through design and development, test, and manufacture of the prototype—thus setting the accepted pattern for industrial production. . . . We do not covet the production load. . . .

The third management concept falls somewhere between these two. . . . The Pershing ballistic missile system is an example. We chose to design the inertial guidance system because we had the demonstrated competency. On the other hand, we will not produce the system—that will be done by a subcontractor working from our design.

It ought to be self-evident that in order to conduct a development and production program by any one of these methods we must perform some in-house work to keep abreast of the state of the art. If we lack the technical management ability to deal intelligently with industry we would, in effect, be dodging our responsibility to provide every assurance that the weapon will perform as it was designed in the combat environment.

When that weapon means life or death to the soldier, and perhaps victory or defeat to our cause, we are the people who stand in judgment. That is our total obligation and it is one which we cannot share with industry.

Maj. Gen. Gunnar C. Carlson
Chief, Industrial Division, Ordnance Corps, United States Army, Washington, D. C.

LET me restate Army and Ordnance policy regarding the use of private industry versus Government-owned manufacturing facilities:

First, the Army relies on private industry for mass production of military Ordnance items.

Secondly, the Army uses the arsenals primarily for job-shop or pilot-line production of military items in support of development, production engineering, and industrial mobilization missions.

Thirdly, the Army uses Government-owned production facilities where no suitable private facilities exist, but relies on private industry, competitively selected, for operation of these facilities.

Our arsenals and plants are essential because of:

1. The specialized nature of Ordnance matériel.
2. The necessity for a reservoir of scientific and manufacturing know-how for munitions.
3. The need for capacity to meet emergencies and fluctuating demands.
4. The necessity for control over quality, prices, and performance.
5. The need for facilities for the training of personnel.

6. The need to safeguard certain research and development information.

7. The impracticability of private investment in facilities for the manufacture of certain military items having no civilian market.

Ordnance plants . . . are Government-owned brick and mortar, with tools and equipment to produce items which have no counterpart or insufficient capacity in the U. S. economy to meet Army requirements. . . .

The arsenals' functions touch on every phase of the life cycle of a weapon from cradle to grave. . . . They . . . are skillful in sensing and anticipating the needs of the combat arms as well as in meeting the expressed needs. . . . They interpret the requirements of the combat arms to industry in terms which permit industry to use its ingenuity to conceive the weapons required by the Army.

The evaluation of feasibility studies and supervision of development contracts is part of the program of the arsenals. To develop and maintain technical competence, the arsenals do some research and development work . . . cooperating with the private-enterprise members of the development team. . . .

The arsenals develop various components for weapons systems they are peculiarly equipped to turn out. . . .

We begin back in the development stage to telescope development and production programs. This requires know-how to supervise and to guide our contractors intelligently in engineering Ordnance for low cost, consistent with reliable performance. We in the Army never forget that the justification for our weapons programs must be successful operation in battle. The battle is the pay-off. Our equipment must be operable and maintainable under the stress of combat.

The arsenals must monitor new equipment for maintainability. Their maintenance engineers know the Army, the possibilities of its supporting maintenance units, and the design situations which have created maintenance headaches.

Supply support means getting to the combat soldier on time the replacement weapons and repair parts he needs to sustain combat operations, the technical experts determining what repair parts will be bought to support new weapon systems. . . .

Arsenals do a tremendous technical job for the Army, for the Department of Defense, and for the Nation.

Our arsenals can fulfill uniquely the role of ordnance production advisers in industry. . . . They prepare procurement specifications and drawings for new items, and they supervise the same sort of work by our development contractors. . . .

By pilot-line operations the arsenals prove out the drawings, specifications, and inspection procedures for new items. . . .

The arsenals are the training headquarters of our procurement inspection staff. Seasoned arsenal inspectors provide the experience needed in a realistic training system for inspectors. Specialized laboratories establish the plan and control the gages and other inspection equipment used in contracts. . . .

Our aim is reliable equipment on time. We can maintain reliability in production by adequate quality-control measures. To do this, we again build on the arsenal system. Reliability, it can be said, is a function of the design of equipment. . . .

For the fiscal year 1960, of about $2 billion spent by the Army for hardware, $55 million, or about 2 per cent, was for production in the arsenal system. Out of research and development expenditures of approximately $1 billion, $132 million were spent in the arsenal system. This includes $90 million for missile development in very advanced and very specialized categories which could not be done elsewhere.

W. Miller Hurley

Vice-president, Winchester-Western Division, Olin Mathieson Chemical Corporation, New Haven, Conn.

THE new M14 rifle is better than the M1. It fires the 7.62-mm. standard NATO cartridge, which is smaller and lighter and packs the same punch. It provides more firepower, since it fires selectively semi- and full-automatic from a 20-round magazine instead of semiautomatic only from an 8-round magazine.

These advantages have been achieved with a net loss in weight. The M14 replaces the M1 Garand, the M2 carbine, the Browning automatic rifle, and the M3A1 submachine gun.

This weapon was carried through its initial design and development under . . . the arsenal concept. Our first objective was quality, and, tying for second place, quantity and cost. Three separate make-or-buy analyses were made to determine the best combination of in-house and purchased parts.

To achieve minimum production costs it was necessary to introduce new production methods . . . for our commercial rifle line as well as . . . still more advanced processes . . . aimed toward reducing labor costs and improving quality. . . . The most outstanding innovation was . . . a joint effort between Olin Mathieson and the George Gorton Engineering Company of Racine, Wisconsin. This transfer machine performs thirty-two operations on the M14 receiver using a single operator.

Team efforts can begin at the establishment of the requirement. If, by early discussion with Government technical personnel, industry can establish that a problem or a general requirement does exist, much time and many dollars can be conserved.

The next step gives industry the greatest opportunity to contribute a preproduction-engineering phase. Industry must thoroughly evaluate the design criteria and must determine the machinery and equipment available in Government layaway.

Springfield Armory utilizes standard machines and equipment and industrial contractors to meet production rates, develop new processes, tools, fixtures, and gages.

The final step is the production phase. Industry has to accelerate its facilities, manpower, and productive capability far past the normal rate of growth.

We recognize the inherent difficulty of advance planning, and we feel there should be greater continuity in preparing to gear up to produce rifles. Mobilization bases, their machines and equipment, unless maintained, are . . . rapidly outmoded in today's accelerated technological developments.

If there was some continuity through industrial research and development an enormous amount of time and dollars could again be conserved.

The M14 Springfield rifle is the first new design industry has had to produce in nearly twenty years, and it has been very difficult and exceedingly expensive to gear up rapidly to requirements.

We are going to make the M14 rifle that will be known as a gun that was successfully developed and produced during economic crisis, cold war, and during a period when missile and space programs were more glamorous than the best gun.

Paul L. Davies

Chairman, Food Machinery and Chemical Corporation, San Jose, Calif.

THE Ordnance Division of our company is capable of providing a complete program starting with concept studies, progessing through design and pilot fabrication, and culminating in quantity production. The personnel are occupied entirely with military projects, and our other commercial divisions and mechanical and chemical research agencies are immediately available to assist.

The "austerity" power package, together and with other savings, helps reduce the cost of the M113 materially below that of the vehicle it replaced. The M113 actually affords more protection, and it is faster, more maneuverable, carries a larger load, has almost twice the fuel economy, weighs less than half as much, transports more troops, is made of more expensive materials, and can be dropped by parachute.

The last M59 personnel carrier and the first production M113 armored personnel carrier were delivered to the Government on schedule and on the same day, February 29, 1960.

The largest problems were the new aluminum welding methods and techniques developed due to the introduction in production for the first time of aluminum armor. Welding schools, with teachers and teaching equipment, were established—there were no design criteria, and known techniques were not adequate to make an acceptable product at a reasonable cost.

As one outstanding example, welding operations were reduced from 22 passes to 2 passes on approximately 900 inches of welding and increased the strength of the hull.

We helped to achieve the Ordnance Corps concept of a family of combat vehicles in which each uses the same major components and the same high-mortality parts.

We believe it is our job and that of other junior partners on the Ordnance-Industry Team to achieve cost reductions, to introduce manufacturing and technical improvements, to develop superior designs, but above all to produce good, reliable end items—on time and in the necessary quantities—so that our armed forces will be always prepared.

Walter G. Herr

Assistant Project Manager, Western Electric Company, New York, N. Y.

THE Nike is a representative example of "out of house production." This responsibility has produced two generations of missiles—Nike Ajax and Nike Hercules. A third generation, the Nike Zeus, is the only active defense now in development against intercontinental ballistic missiles.

Our design objectives, in addition to mobility, are:

1. A system for use under wartime conditions by GI's.
2. High reliability, efficiency of operation, the greatest simplicity, and the lowest cost of expendable equipment.
3. High probability of "kill."
4. Safety for operating personnel and noncombatants in the area.
5. Control of the missile at all times.

The single-manager approach was found to result in successful production. Need for a single manager occurs when a complex weapon system demands the broad research and development experience of a systems-conscious technical organization and the industrial know-how of an experienced managing-manufacturing organization.

We view our subcontractors as a vital network that feeds in material and data and we appreciate their recognized competence. Spare parts must be selectively stocked, technical manuals painstakingly prepared, and the Army trained.

We have the able advice and support of the expert military and civilian team of the Army Ordnance Missile Command. The Army has purchased more items directly from our subcontractors with a resultant saving of the taxpayers' money.

Nike enjoys the distinction of being the first completely operational major missile system in the field. Our improved Nike Hercules has knocked down a Corporal missile and has killed other Hercules missiles—because no target rivaling the Hercules in speed and altitude has been available.

The supreme challenge is the ICBM and the IRBM—and Nike Zeus is the only system being developed to neutralize them. We are confident that the job can be done.

Production for the Navy

Highlights of the papers given during the seminars on America's production of defense weapons at the Forty-second Industrial Preparedness Meeting of the Association held in New York City

Rear Adm. P. D. Stroop

Chief, Bureau of Naval Weapons, United States Navy, Washington, D. C.

THE Navy expects to depend upon industry for the design and development of our weapons systems. For aircraft and most of our major missile systems we will use a performance specification and select a contractor through a design competition.

On some of our weapons we will use our in-house research and development facilities to spell out in more detail the parameters of what we want. We may actually build and test the prototype, but we will depend upon industry to develop and produce the weapon for us.

A second point I want to make is that award of the first production contract will be made to the research and development contractor provided (a) extensive preliminary research and development work is involved which can be put to most effective use in production by the research and development contractor, (b) there is a need for continued improvement of the equipment, and (c) the economy of going elsewhere cannot reasonably be justified.

We are interested in obtaining optimum competition, but it is not our desire to bring "in-house" or make competitive a weapon which has not been fully developed.

In those weapon systems where we have called for complete documentation, and after the first production contract with a stable design, we may choose one of the following paths for the second production contract:

1. Second source or multiple sources to improve our mobilization base and to provide for cost reduction through competition.

2. Competition through advertised competitive bidding—sometimes with full or partial small business set-asides.

3. We may go "in-house" for second and subsequent production contracts.

Our "in-house" policy will be discussed in more detail later.

The trend is toward an over-all weapon system approach—and the term "weapon system" appears in our recent contracts for major weapons. We are depending more upon a single contractor to pull all technical aspects of a complex weapon system together.

In no case, however, will this Bureau delegate management control of a weapon system to the prime or another contractor. We intend to manage all our programs in the Bureau. It is expected that our own research and development laboratories will be called upon to exercise technical direction of our important weapon systems. This puts these laboratories in the position of being an extension of the Bureau for certain responsibilities. Our contracts will define these responsibilities and the laboratories' relationship to the Bureau and to the contractor.

Rear Adm. Joseph E. Dodson

Assistant Chief, Bureau of Naval Weapons—Fleet Readiness, United States Navy, Washington, D. C.

FOUR important and interrelated aspects of naval weapons production are: In-house production policy, facility policy, types of contracts, and other features to be expected in our production contracts.

Out of the $2.5 billion of procurement funds available to the Bureau of Naval Weapons for procurement in this fiscal year, only about $80 million, or just over 3 per cent has gone to our "in-house" plants for production. In direct support of the fleet, we must maintain overhaul, repair, and rework capacity to handle combat models of aircraft and missiles. A part of the mission of these facilities is to train our sailors for their wartime job. We also will produce weapons "in-house" where quantities are limited and the required facilities are complex; that is, in job-shop production.

Thus our "in-house" capability supplements industry and in so doing as-

sures that our joint Navy-Industry Team is adequate in peacetime as well as in war to support the greatest Navy in the world.

Reemphasis is being placed on a long-standing policy to require our contractors who expect to remain in the defense business to have the tools of the trade—or to provide their own facilities. BuWeps is attempting to get out of the facility business. In so doing we relieve ourselves of a continuing and complex problem of managing extensive facility holdings. This Bureau also is reappraising the need for retention and continued government support to over 600 private contractors who hold BuWeps-owned facilities.

This Nation cannot, and should not, maintain and operate Government-owned industrial-type capabilities which are in competition with private capital and the American system of competitive free enterprise.

It is appropriate in any discussion of production to consider the types of contracts we should use during each production phase. The first contract for development of a weapon system will normally be a cost-plus-fixed-fee or a cost-type contract. This provides some measure of protection for the Navy and its contractors where accurate pricing is difficult to estimate.

We would encourage the use of incentive features at this point in a cost-type contract if it is appropriate and we can agree upon the terms.

Our first production contract will definitely then go in the direction of an incentive or profit-sharing contract. The second and follow-on production contracts, whether we go sole source or competitive, will be fixed-price.

We think the fixed-price contract provides the greatest possible incentive to the contractor; therefore, we are willing to allow a higher estimated profit because of the greater risk assumed. And we will take a fixed-price contract at any point in the proceedings, even on the first research and development contract.

BuWeps feels that reliability is definitely the responsibility of our contractors. Reliability must be a part of the initial design concept. Often you can improve reliability through design simplification and at lower cost. We would like to see performance specifications and production schedules in all contracts with penalties for failure to meet either. Let me remind you again, however, we plan no unilateral action here—a contract is a mutual agreement between two parties.

Henry F. Argento

Vice-president and general manager, Philco Corporation, Philadelphia, Pa.

THE Sidewinder missile was initially conceived and designed by the Naval Ordnance Test Station in California and the production engineering work was done by Philco. It may have fewer parts than a number of the other missiles, but it is basically a sophisticated, high-precision, electromechanical device.

The volume requirements were sufficiently great that, after the initial production run, two sources could economically be justified. The Navy Department made it quite clear to the two sources that the amount of business either one would get would be entirely dependent upon their over-all performance.

One of the first things that Philco did to improve its production was to establish a value-analysis group consisting of representatives of purchasing, engineering, methods, and quality control. The guidance-and-control unit was broken up into nine separate packages, and management assigned a task to this group of reducing costs by thirty per cent.

A number of improvements were effected by the value-analysis group. Initially, cylinder blocks were individually drilled and honed. An improved automatic type of machine lathe as well as special alloy tools were purchased so that all four cylinders could be shaped simultaneously. Cost of these cylinder blocks dropped from $65 to $18. A machined special alloy steel housing for a 60,000 r.p.m. electrical generator costing $100 was converted to a precision casting costing approximately $5.00. Precision system testing equipment was redesigned to permit automatic testing and recording. All of this involved many changes in the missile, but we were able to effect them promptly due to the close teamwork that was maintained between Philco and the Naval Ordnance Test Station.

A real competitive spirit was generated with our labor force to the point that they were continually asking how our costs compared with what we thought our competitor was doing.

These many changes could have affected production very seriously. Fortunately the Navy agreed to support a pilot production line, so that changes were never introduced into production without first having been checked out thoroughly and proved on a pilot line.

I cannot overemphasize the importance of not introducing changes into a fast-moving production line without their first having been thoroughly checked out from parts made on production tools on a pilot-line basis.

Another major factor in cost reduction was the insistence that some of the components be produced in-house. The effect of an integrated capability kept our suppliers on their toes, permitted us to teach our suppliers better ways of manufacturing, and made it easy to learn what components must be emphasized.

A very high ratio of inspection and quality control was used in manufacturing so that smaller subassemblies could be thoroughly checked out and charged as either good or bad at a relatively low-cost point. To reject or repair a five or ten dollar unit is far cheaper than to inspect larger units.

The principal elements which have brought about this improvement are multiple subcontractors, pilot-line production, value analysis, the control of operations at relatively restricted points, and in-house manufacturing.

John B. Hawley, Jr.

Chairman of the Board and President, Northern Pump Company, Minneapolis, Minn.

THE production of naval ordnance machinery, such as gun mounts and guided-missile launching systems, at reasonable cost today requires adequate housing and accurate, modern machinery.

With this requirement taken care of, the production job of my company—Northern Ordnance, Incorporated—then resolves into two factors: (1) The basic concept and design of equipment that will perform to specification and can be manufactured at reasonable cost; and (2) the operation of a 3,000-man job shop at minimum cost. This includes the welding shop and foundry.

The hiring, training, and supervision of several thousand men to work together in harmony at peak efficiency is the key to producing serviceable large navy ordnance.

The wide variety of parts which we manufacture for only a few production units at one time requires extreme flexibility in our shop management. We must be able to shift men from one type of machine to another and from the machine shop to the assembly line at any time. The top pay for the machinists and the assembly men is the same.

We have excellent employee understanding at Northern Ordnance, Incorporated, where any one of my 3,400 fellow workers can dial my telephone directly or visit my office without prior notice. If an associate has a serious problem, he can telephone me at home.

When an employee or his wife goes to the hospital, he or she immediately gets flowers with the president's personal card, and our personnel manager calls. Every Christmas every employee gets a useful present from me personally. On our parking lot we provide an automatic drive-through wash rack, free repair of flat tires, and a truck to start balky cars.

We take full-size chest X-rays of our employees every year and pay for eye examinations.

Northern Ordnance, Incorporated, vigorously promotes an employee recreational program in which a third of our employees participate actively.

Our employees have never been represented by a union. At our last union election five years ago I was accused of: using brain-washing tactics, using double talk, giving pay raises whenever the union threatened, and many other things. The results of the election were: No union, 2,048 votes; UAW-CIO, 503 votes; and AFL (International Association of Machinists), 88 votes.

To solve the problems which arise in the production of modern complex Naval ordnance requires the constant attention of top management and engineering talent. The increasing burden of preparing completely documented quotations and progress reports as required by existing contracts has seriously reduced the time and effort which can be applied to the solution of production problems.

We must realize sooner or later that economical production of high-quality ordnance cannot be obtained by regulations, directives, and documentation. Every contractor needs freedom to use to the fullest his own individual and unique capabilities and not be forced to work in a climate of regulated mediocrity.

Dr. Ernest Roberts

Assistant Plant Manager, Solid Rocket Plant, Aerojet-General Corporation, Sacramento, Calif.

THE sheer size and cost of the new large rocket motors necessitate the introduction of new techniques and, sometimes, new philosophies in their production compared with small rockets.

In the processing there is only one substantial difference, and that is the mixing and casting operation. Although the technical problems involved in the processing of several batches for one single rocket have been resolved, the development of a continuous-mix technique was determined to be more suitable for large rocket production. We now have an intensive and continuous quality control of the mix at a substantial reduction of processing labor costs and with increased safety of operation.

In this process all critical ingredients in respect to weight composition are monitored to assure the proper composition of the final propellant.

Periodic static firings of production motors are made as spot checks, but the primary emphasis is on the "in-process" control and on the extensive utilization of nondestructive testing. Large solid-propellant motors are subjected to a series of nondesructive tests prior to shipment to the customer.

Based on the correlation between the nondestructive tests and firings of large solid-propellant motors, acceptance criteria have been established for the Polaris presently in production, covering propellant-liner bond, steel-to-insulation bond, and voids in the propellant grain.

The design of large rockets is complex. Substantial improvements in efficiency were required, demanding higher specific impulse, lower weight of inert components, and the introduction of thrust-vector and thrust-termination devices that in turn required new design concepts and the use of new materials.

A part of the task facing us is the preparation of adequate but not overly stringent specifications on materials which only recently found use in the rocket industry. Frequently we are imposing demands on materials which make their manufacture difficult.

In summary, the production of the Polaris power plant in less than three years after the initiation of its development represents a significant achievement of the Navy-Industry Team and an accomplishment to be proud of.

Air Force Production

Highlights of the papers given during the seminars on America's production of defense weapons at the Forty-second Industrial Preparedness Meeting of the Association held in New York City

Lieut. Gen. Mark E. Bradley, Jr.

Deputy Chief of Staff, Matériel, United States Air Force, Washington, D. C.

IT seems to me that among the many dangers we face today not the least is the danger of becoming so enamored with new and exotic weapons that we lose sight of our present defenses and defenders. The B-52, B-47, and KC-135 are today's deterrent.

These are the weapons of which there are hundreds on 15-minute alert all over the world today. They've been there and have been increasing in status and numbers for several years. Included are the thousands of SAC crews who are doing a job for the free world today. This is the kind of talk an enemy understands best.

The F-106 and F-101 are our latest operational interceptor aircraft. Hundreds of these, too, are on instant alert all over the world. It is the hundreds of pilots and radar operators of our Air Defense Command that we must not forget.

The F-100, a long-time stand-by of our tactical forces and the first quantity-produced supersonic fighter in the world, and the hundreds of TAC crews are also not to be forgotten when we discuss our present Air Force power and capabilities.

The ballistic missile early warning system at Thule in Greenland was on the air and operational since last October in accordance with the objectives set two years before the time of completion. This is the first warning station of three. One in Alaska is well along, and one in Scotland is under construction. I am proud of our Air Force people, the Corps of Engineers, and our contractors who carried out this terrific job.

Maj. Gen. W. Austin Davis

Commander, Aeronautical Systems Center, Air Matériel Command, Wright-Patterson Air Force Base, Ohio

THE tremendous investments of both industry and government in the basic and applied research fields throughout the past decade are now giving us an extremely wide variety of weapons alternatives to accomplish essentially the same military missions. We are not only presented with these alternatives within each service, but also across the services.

Within the Air Force we are continually facing the problem of arriving at the proper balance between the manned and unmanned versions of air and space weapons at every step of the process from original idea to combat inventory. I would also point out that our present range of choice clearly indicates that there can be no dependence on a single "ultimate" weapon.

While we cannot deny ourselves or the Nation the systems that are necessary for superior military strength, we cannot at the same time afford the luxury of costly duplication or of ineffective assets.

We can no longer give time, dollars, attention, and resources to new systems that provide only small, incremental improvements over existing systems. If we are to maintain the vital superiority in weapons, we must be concerned with the wide-step advances or "quantum" jumps that technology is now capable of giving us.

Despite our having multiple means of accomplishing the same mission, the over-all number of systems which will be in concurrent production for the combat inventories will decline significantly. This is the direct result of the scope and technical cost in resources, dollars, and time required to give us the wide margin advances that justify our investment.

Accompanying this declining number of systems will be a reduction in the total volume of hardware for each sys-

tem program. This is because of the tremendously increased potency and effectiveness of modern weapons systems.

The weapon-systems concept for developing, producing, and operating new military matériel is a practical managerial and operational necessity for both the services and industry.

Since we are conceiving and developing weapons for operation in environments which can only be poorly simulated on the surface of the earth, we must produce enough test versions of the weapon to prove their functional and operational worthiness. These test quantities generally involve the use of hard tooling and very sophisticated production processes and techniques calling for production-type capital outlays.

Another managerial innovation that is becoming an integral part of our management is the use of automated data systems for comprehensive management data on the progress of our systems work.

The Navy led the way for this managerial innovation with its development of the PERT system which, with certain modifications, we call the PEP program or program evaluation procedures.

Both we and industry are finding that the planning, scheduling, and conducting of tests is becoming as important as that which is associated with the manufacture of the weapons. Since these tests are usually taking place at locations remote from the seat of industry management or from government management, we have had rather severe communications, data, and staffing problems in order to stay on top of this important segment of our operations.

Test failures have a significant impact on the scheduling and instrumentation of later tests, and we will need increasingly sophisticated systems for information and control in this area of management.

Dr. Norman Grossman

Chief, Equipment Engineering, Republic Aviation Corporation, Farmingdale, N. Y.

THE design requirements for the F-105D, as established by the United States Air Force, were for a versatile, one-man, supersonic fighter-bomber capable of performing three basic missions: (1) an all-weather low- or high-altitude penetration and nuclear strike, (2) strafing and bombing of enemy forces in support of our ground troops, and (3) interception of enemy aircraft deployed against ground or air targets for establishing air superiority over a battleground.

A giant step forward in all-weather capability was achieved by adapting a new integrated bombing-navigation system to the F-105B engine-airframe combination. By the judicious application of automatic controls and computers, the pilot flying the F-105D accomplishes the combined roles of pilot, navigator, radar operator, and bombardier while flying blind at supersonic speeds close to the ground.

The integrated weapon system includes: central space reference, central air data reference, automatic flight control system, automatic navigation system, and the Thunderstick fire-control system which is the heart of the weapon system.

Since a computing system cannot be more precise than the input data, the weapon system is equipped with basic sensors which make accurate measurements of the parameters needed by the various subsystems in applying automatic control. Duplication is minimized by sharing these fundamental data sources with all subsystems needing this information. This intimate sharing of equipment by many subsystems is referred to as an integrated electronic system and is a key design feature of the F-105D.

A packaging concept was followed in the F-105D which enables the rapid removal of components on a module level for the incorporation of minor redesigns as soon as service experience shows the need for these changes.

The complexity of the aircraft wiring has resulted in the application of automatic circuit analyzers in final assembly to check circuit integrity, continuity, and shield isolation. Just prior to delivery the aircraft is test flown to verify the functional adequacy and accuracy of the integrated electronic systems.

This phase of the production cycle has been and still is our most difficult task. The basic difficulty appears to be organizational in that cycle operations of a routine nature must be separated from those requiring a high level of technical skill. Unfortunately, the state of the art has not progressed to the point where unskilled labor can handle the complete job with go, no-go, type test equipment.

Therefore trouble-shooting teams of technicians, engineers, and supplier representatives analyze pilot-reported discrepancies and supervise the corrective action required. As the general experience level increases, it is hoped that the entire task can be put on a cycle basis without engineering assistance.

J. R. Dempsey

Vice-president and manager, Convair Astronautics, General Dynamics Corporation, San Diego, Calif.

ALTHOUGH General Dynamics corporation is the dominant industrial firm in the Atlas missile program there are other companies which are also prime contractors on Atlas, and there are literally thousands of subcontractors and suppliers in the United States which have each made definite contributions to this missile system.

The Air Force, of course, is the catalyst that is meshing all this work into a meaningful whole.

The present Atlas program was begun in earnest in early 1955. Flight tests began only sixteen months after the official go-ahead, and by the fall of 1958 all the basic design features of the Atlas had been proved out.

The bird was declared initially operational the following year—in September 1959—and at present the weapon greatly exceeds—in both payload and range—the most optimistic expectations that we had in 1955.

All our production planning revolved around the two central facts of life on the Atlas program: First, that this was a "hybrid" sort of production program—a cross between one-of-a-kind hand-made prototype construction and a full-blown production line of the aircraft type; secondly, that we would be in production simultaneously with prosecution of the flight-test program.

This meant that our manufacturing procedures must remain flexible enough to adapt readily to new information developed in the test program. Previously, we had not encountered the close tolerances that the missile demanded—work at tens of thousandths of an inch—which was much more precise than aircraft work but in missile manufacture may be thought of as fairly "sloppy" work.

The Air Force took the calculated risk that the information that we got from the flight tests could be incorporated successfully in a production line which was in simultaneous operation. As a result, our missile-production people need to know, in detail, where every part of every missile is located.

When trouble occurs on a flight test, the information which is radioed back to the ground from the missile will usually tell in what part of the missile's mechanism the trouble occurred. The next thing to do is to go back and examine all similar components and try to discover what happened.

This means that we must know exactly how each of these birds was put together—what kind of relay, or cabling, or switch, or valve, or tubing, or whatever, was in the missile that was flown from Cape Canaveral, and how it was installed, when, and by whom.

In Atlas we encountered for the first time in weapons production broad requirements for surgical cleanliness—cleanliness measured in microns in some instances.

These standards, in order to be effective, must extend to over 3,000 suppliers and subcontractors who contribute to the Atlas.

Dale Myers

Missile Development Division, North American Aviation, Inc., Los Angeles, Calif.

IN mid-1957, the Air Force, recognizing the need for a means of extending the useful life of their prime strategic weapons system, the B-52 bomber, initiated a competition and subsequently awarded the contract for the development of the GAM-77, an air-to-surface missile weapon system.

The weapon was to achieve the Strategic Air Command's objective of providing a penetration aid for the B-52 and in addition have a "stand-off" bombardment capability for primary targets.

The Hound Dog program, as it is popularly known, with the Missile Division of North American Aviation, Inc., as prime contractor, contains all the facets of missile, pylon, carrier aircraft equipment, ground support equipment, facilities, training, and logistics support that comprise a complete weapon system.

The Hound Dog is a supersonic missile, launched from the B-52 intercontinental bomber. The B-52 carries one missile under each wing mounted on a special pylon that contains some auxiliary equipment associated with alignment of the inertial guidance system.

It is an extremely flexible weapon in that the navigator in the B-52 can change the launch point and target, select a high- or low-altitude trajectory,

and pick a straight line or evasive flight path to the target prior to releasing the missile in flight.

In February 1958 we were instructed to proceed on an accelerated program which involved the Air Force principle of concurrent development.

Very simply, this principle accepted the simultaneous conduct of the contractor's development flight test program, the Air Force-conducted operational suitability test program, and the early production associated with concurrent introduction into the Strategic Air Command inventory, all in the interest of the earliest possible operational capability.

The goal of achieving the earliest possible operational date indicated the use of existing hardware wherever possible. Nothing was designed into or planned for the weapon system that required invention to be scheduled.

The most advanced subsystem, of course, was the airborne guidance equipment, and although there was no existing guidance system which would completely meet the GAM-77 requirements, the principles of inertial navigation and many of the components making up the inertial system had been demonstrated or were in advanced stages of development.

The inertial guidance system consists of a gyrostabilized platform with instruments that measure motion through space, a transistorized digital computer, and associated power supplies and amplifiers. An astrotracker in the pylon is used to establish azimuth prior to launch. The system is independent of winds, unaffected by electronic countermeasures, and once launched it is impossible for enemy jamming to interfere with it.

The Air Force standard is to accept only those systems which give a resultant error during factory test equal to the specified flight accuracy for twice the flight duration.

Forty-third Annual Meeting

AMERICAN ORDNANCE ASSOCIATION

Los Angeles, Calif.

The Forty-third Annual Meeting of the Association—this year under the auspices of the United States Navy—will be held in Los Angeles on Tuesday, May 16th, and at sea with the Navy on Wednesday, May 17.

● On May 16th the Statler Hilton Hotel in downtown Los Angeles will be A.O.A. headquarters. The program will start with a luncheon to honor Pacific Fleet commanders who will describe over-all fleet operations. At afternoon seminars Navy, Marine Corps, and industrial experts will discuss missiles and missile testing, underwater ordnance, amphibious landings, the Polaris, and defense of the air space. At the Annual Dinner, Rear Adm. P. D. Stroop, Chief, Bureau of Naval Weapons, will receive the Association's Blandy Gold Medal.

● On May 17th members will embark at Long Beach and Terminal Island for a day at sea with a Naval Task Force to witness fleet exercises and tests of naval aircraft, missiles, guns, and underwater weapons. Members have been invited to cruise on all ships of the Task Force including a carrier, cruisers, and destroyers. Space is limited so that applications will be filled in order of receipt. Reservation forms for the meeting are available on request.

New Antitank Weapon

The lightweight XM72 antitank weapon, above, can be carried and fired by one man. Top to bottom, below, are the high-explosive, folding-fin rocket projectile; the carrying case-launcher with telescopic section extended; canvas strap for carrying the weapon slung over the shoulder. The plastic launcher can be discarded after firing (Army photos).

Battle under the Sea

(*Navy photo*)

Ballistic missile firing submarines create an "inner-space" battlefield

T. M. Robertson

FOUR recent events combine to reveal our most challenging and neglected battlefield. In August 1958 the nuclear submarine NAUTILUS crossed the Arctic Ocean from the Pacific to the Atlantic while submerged under the icepack. In January 1960 the bathyscaph TRIESTE dived to 35,800 feet in the Pacific's Mariana Trench.

In May 1960 the U.S.S. TRITON completed a round-the-world voyage submerged for the entire distance. Finally, in July 1960 the Polaris fleet ballistic missile was fired underwater for the first time from the submarine GEORGE WASHINGTON.

THE successful Polaris firing climaxed this series of momentous accomplishments. When we view these accomplishments as repeatable by other nations, especially the Soviet Union which already has history's largest peacetime submarine fleet, the picture is sobering indeed.

We now face the prospect of a submarine force that eventually can roam all the world's oceans, including those covered by icepacks, at depths ranging to the deepest chasm—and do this for months without surfacing or replenishment. If it is to the enemy's advantage, this submarine force could also launch from these vast ocean reaches ballistic missiles capable of speeding hundreds and thousands of miles to destroy their inland targets in the free world.

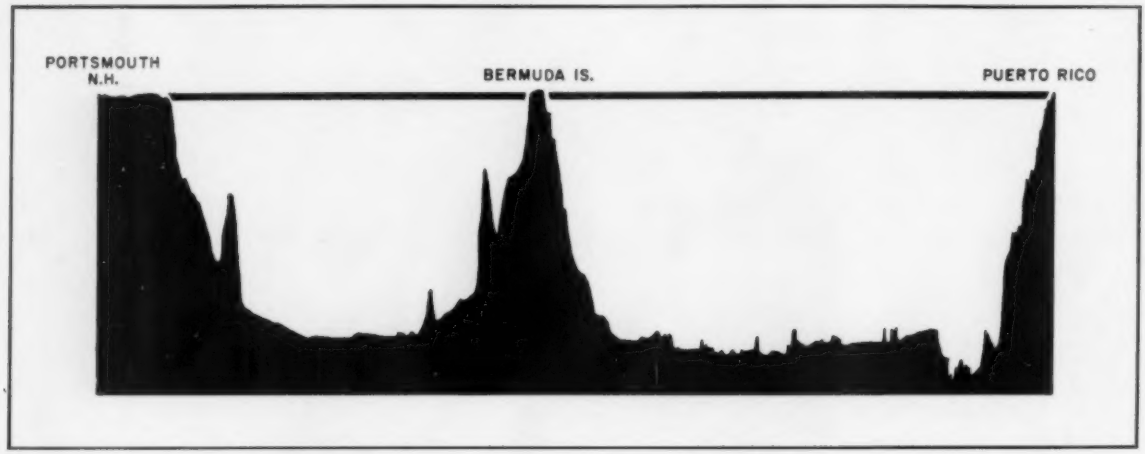
Mr. Robertson administers a broad program of undersea weapons development including torpedoes, fire-control and launching systems, mine-hunting and mine-sweeping systems as head of the Systems Development Department for Vitro Laboratories, Silver Spring, Md.

What can we do about today's tremendous submarine threat and tomorrow's even greater threat? What capabilities do we have to neutralize it?

The answer is alarming. Relatively speaking, we can do little more in antisubmarine warfare now than in World War II. The German submarine campaign in 1942 prolonged the war and threatened to undermine Allied strategic planning. Tremendous effort and dedication succeeded in containing this threat. But now we potentially face a much greater threat with a defensive capability that is only incrementally improved.

WE have succeeded, of course, in pushing out the range at which we can detect, localize, and neutralize an enemy submarine. We have increased by a modest amount the depth at which we can make successful attacks, and we are capable of attacking targets of somewhat greater speed.

But these technical gains have not kept pace with the capabilities of offensive submarines. Significant gains have been brought about by the development of improved antisubmarine-



Ocean floor from Portsmouth, N. H., to Puerto Rico. Top band indicates approximate depth reached by today's subs.

warfare tactics by the operational forces. These forces have succeeded in wringing every last ounce of potential out of the weapons systems available to them. They have done their best to make do with what they have.

Unfortunately, our technological achievments, even when coupled with improved operational know-how, look feeble, indeed, when viewed against the four historic events highlighted above. The tremendous improvement required in our antisubmarine weapons is clearly illustrated by considering only one parameter, that of depth.

During World Wars I and II—and indeed almost to the present time—we have been concerned essentially with a 2-dimensional battlefield in the ocean. Submarines have traditionally had rather limited depth capability of the order of 400-plus feet. If we view this operating capability in the light of the actual depth of the ocean as illustrated above, we have a graphic portrayal of the significance of the dives of the bathyscaph TRIESTE.

One fact alone is of the utmost importance. That fact is that we cannot see the submarine in its environment—the ocean gives it a cloak of secrecy and an element of surprise. Much has been written in recent months on the problems of underwater detection stemming from our inability to propagate energy in sea water to effective ranges. Great effort has been expended on investigation of the complete electromagnetic and acoustic spectra in order to exploit them for detection.

This matter of detection and localization is considered by many to be the most serious problem facing us in antisubmarine warfare. Everyone hopes for a break-through, although few are counting on it. But, pending a break-through, we are forced to contend with the vagaries of underwater sound transmission. The fact that detection, classification, and localization constitute our most important problems will assure that each will get its share of attention.

That is why I fear we are in danger of overlooking our weapon requirements. Our weapons today are marginal in performance as compared with the performance of our latest submarines. They will be woefully inadequate against tomorrow's submarines. Constructive and effective work is under way to improve this situation. There are new weapons systems with entirely new concepts coming into being. However, these forthcoming systems are predicated upon a tactical situation that will possibly be with us for a short time.

We need now to be looking at what will be the full impact of our four significant historical events. Their combination and full exploitation in submarine warfare are inevitable. We must be ready to deal with that situation.

The U.S.S. TRITON cruises on the surface just before her historic dive beginning the first submerged circumnavigation of the world (Navy photo).

Fighting for control of the ocean depths is not likely to be for reasons of control of those depths alone. Undoubtedly it will be for a more compelling reason. Enemy submarine forces will have a mission of their own. The most obvious and frightening mission is that of the strategic bombardment of the U. S. mainland by ballistic missiles.

In planning future weapon systems we must assume that enemy ballistic-missile-firing submarines will be capable of operation at great depth and will be capable of quiet propulsion. The enemy certainly will study the ocean environment and take full advantage of all possible capabilities, such as stealth and depth.

I predict we will not cease attempts to operate at increasing depths until the ability has been acquired to operate at the greatest depths that exist in any part of the ocean.

IF this capability is coupled with that of quiet propulsion, the problem of detection and localization is multiplied. If the enemy is quiet, a passive detection system will give us only short range at best. If he is capable of following the contours of the ocean's bottom, regardless of depth, some of our most significant advances in sonar detection techniques will be ineffective.

In addition, operation at great depth will severely handicap our surface and airborne ASW forces. Thus one can conclude that to fight the enemy under these conditions we muust be able to go in after him.

To do this we will need submarines capable of operation at great depth carrying detection, classification, and localization equipment to where their limited range can be effective. Obviously, we need a weapon to complete this weapon system. As so often happens, one of our oldest weapons gets a new lease on life through other technological advances. I believe that it is true in this case.

Present-day weapons such as Asroc and Subroc that use a composite air-underwater flight have tremendous potential against today's submarines. However they seem somewhat impractical if both the hunter and the target are ten miles apart and five miles deep. At depths such as these it seems that an all-water trajectory will be preferable. This calls for a torpedo for use in close-in fighting.

There are many traditions and a long history associated with torpedoes, but we must not let these traditions and illustrious past history blind us to bold new concepts. Calling our weapon an underwater guided missile, as is the current practice in the Bureau of Naval Weapons, is conducive to the kind of mental progress needed. These future underwater guided missiles will bear slight physical resemblance to the familiar torpedo.

One of the major advances that occurred in underwater weapons after World War II was the development of midcourse guidance by means of a trailing electrical wire. Wire-guidance of underwater missiles brings to these weapons all the advantages associated with our ability to command-guide airborne missiles.

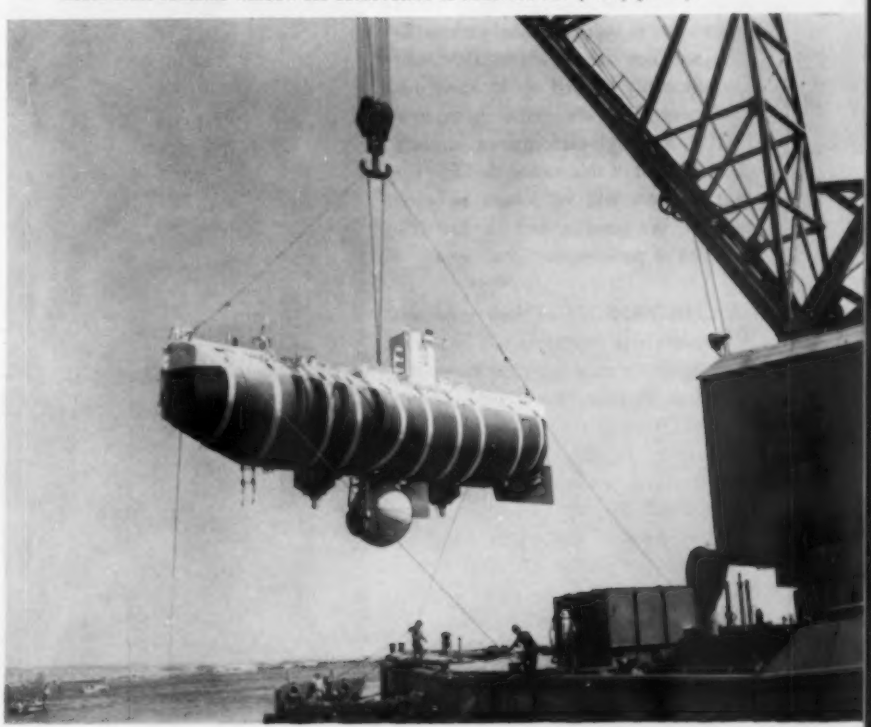
To obtain hits, we no longer must have a complete and accurate solution for target motion with an accurate prediction of future target position. Rather we can fire our missiles on the basis of fragmentary information and continue to employ new information throughout the flight of the weapon. This capability permits significantly increased effectiveness while at the same time permitting a reduction in system complexity.

THE homing torpedo, as developed in World War II and as greatly improved since that time, brings a desirable capability to our future weapon systems. This ability to home on a target permits a weapon with a small explosive charge to have the lethal range of a much larger explosive charge—indeed to approach the effectiveness of a nuclear warhead.

There are some indications that we will find it desirable to fight future naval engagements without the employment of nuclear warheads. The ability to achieve large effective ranges without the use of nuclear warheads offers this significant advantage while at the same time reducing the cost of the weapon.

Further improvements are needed in our operational antisubmarine torpedoes. Today's high-speed submarines already can outrun some of our older torpedoes, particularly if you consider

Floating crane lifts bathyscaph TRIESTE from water. Circular chamber beneath craft contains window for observation of undersea life (Navy photo).



the stern-chase aspect. In addition, our newer submarines can go deeper than some of our older torpedoes. We need torpedo improvements to combat even today's generation of submarines. Tomorrow's submarines will require much greater improvements.

We must urgently seek to reduce the drag on our underwater missiles and to pack more energy into a given space. At best we will be hard pressed to achieve adequate range and speed in a weapon small enough to provide submarines with adequate firepower.

Through the previously mentioned wire-guidance system we may be able to introduce greater sophistication into the weapon. It is well known that classification of targets is one of our major problems. The closer you can get to a target, theoretically the easier it is to classify it. You then come within the range of more of the energy that is radiated from the target and you can study it in greater detail.

For this reason it is logical to believe that the torpedo itself can be employed in target classification by transmission of information back over the wire communication link.

We are at a stage in the evolution of underwater guided missiles where there is much room for improvement. Today's underwater missiles are closely related to blimps. They are relatively slow and are essentially buoyed up by their displacement. What we need is the equivalent of the high-performance aircraft. Achievement of this means that five per cent answers will no longer be good enough. We need to seek the last few per cent of performance in all areas.

ACHIEVEMENT of these improvements in performance will be costly. Here again we must keep our eye on the objectives. Planning for and developing weapon systems that exceed our national economic capability is foolish. It is a trap into which technologists are prone to fall. The typical weapon-system designer finds it difficult to resist the temptation to put all his ideas into a weapon system and to strive for the best. We must be sure that our weapon-system designers are challenged to contain the threat of the enemy at a cost within our means.

Until the long-awaited break-through in target detection and classification is achieved, the limited range that we are presently capable of achieving indicates that we will need large numbers of economical detection and classification platforms to monitor vast ocean areas adequately. This in itself poses a tremendous challenge to weapon-system designers.

OUR present potential enemy outnumbers us in manpower and has greater potential natural resources. We must take steps in peacetime to counteract this unfavorable balance. We must increase the effectiveness of our manpower and resources, and we must stockpile them in peacetime for use in wartime.

Second successful Polaris missile breaks water. Antenna at right from submarine GEORGE WASHINGTON received telemetry data from missile (Navy photo).

Stockpiling of material resources is a well-known concept. I submit that we also must "stockpile" manpower resources. To do this we must use our most talented weapon-system designers to develop sophisticated systems of high performance. The design emphasis must be on low cost and on the system's ability to achieve effectiveness in combat with a small expenditure of relatively untrained manpower.

Thus, by devoting limited but highly trained manpower in peacetime to the development of sophisticated weapons systems, we effectively stockpile that manpower for instantaneous use in wartime.

If anyone should doubt that submarines will eventually be built capable of fighting at the greatest existing ocean depth, let him consider for a moment the significance of some recent scientific discoveries. There are great achievements being made in materials laboratories throughout the country these days in the form of single crystals of pure metals that exhibit tremendous tensile strength.

Consider also the significance of the discovery that certain dying stars in the universe contain matter with a density many thousand times that of any known matter existing on earth today. If this kind of matter does exist in the universe, who is to say that we will not learn to synthesize such materials with astounding new properties here on earth?

THE ocean will remain a critical battlefield as long as it offers concealment. It will remain the hiding place of ballistic-missile-firing submarines, with what that implies, until there is some now-unforeseen break-through in the propagation of energy through seawater. The navies of the world will continue to use the sea as a battlefield in which to employ their sophisticated weapons until we can detect objects in this "inner space" as easily as we can detect them in outer space—in other words, until the ocean becomes transparent.

Lest we forget, an open-skies policy leading toward disarmament will not be effective in this battlefield of inner space.

TO

AMERICAN ORDNANCE ASSOCIATION

The American Ordnance Association has established over the years an admirable record of significant service to the Department of Defense. Through dedication to far-sighted aims and objectives designed to ensure armament preparedness and industrial readiness in time of national emergency, the American Ordnance Association has made outstanding contributions to the advancement of weapons technology and the maintenance of a nation-wide capability for full-scale armament production.

In addition to a remarkable record of major accomplishments, such as its role in the study and revision of the National Industrial Mobilization Plan of World War II, the American Ordnance Association has for more than forty years led the civilian forces of industrial mobilization of the nation, and has become recognized as a vital element in the armament preparedness of the United States. Throughout the Association's long service to the national defense, its activities have been ever characterized by intense loyalty, patriotic cooperation, and practical results. It is, therefore, with deep admiration and great pleasure, that I confer on the American Ordnance Association the Department of Defense Meritorious Award.

Thomas Gates
SECRETARY OF DEFENSE

7 DECEMBER 1960

Presented to the Association at the . . .

42nd ANNUAL INDUSTRIAL PREPAREDNESS MEETING

The Waldorf-Astoria, New York, December 7, 1960

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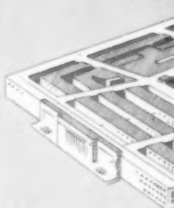

Washington, D.C.
7 December 1960

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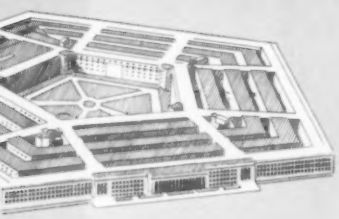


Secretary of Defense

Civil War Ordnance—V

The Revolving Cannon

Although the artillery battles of the Civil War were fought with single-shot weapons, some unique ideas for increased firepower were proposed but lacked the proper technology to achieve success

Donald B. Webster, Jr.

THE American Civil War was not entirely an old-fashioned war with reliance on masses of men rather than weapons, nor was it a true modern war with firepower as the dominant factor. In regard to weapons, the Civil War was more of a transitionary war, beginning with classical arms and tactics but accompanied by extremely rapid developments in armaments.

The impediment to progress presented by the U. S. Chief of Ordnance, Brig. Gen. James A. Ripley, is too famous or notorious to be recounted. The fact remains, however, that in spite of any hinderance the professionally conservative career military could present, by 1865 the Civil War had become a modern conflict with the emphasis on increased firepower.

Many new arms were, in fact, tried and used during the war, particularly small arms. The troops clamored for the best, such as the Spencer repeating rifles and carbines, and when the army hierarchy turned a deaf ear to their requests, they often purchased them independently.

OTHER troops, notably Berdan's Sharpshooters, came close to mutiny in their demands for new arms, in this case Sharps breechloaders.

In the field of artillery the picture was much less rosy. The Civil War was fought with single-shot muzzle-loading cannon, some of ancient design,

Mr. Webster is a graduate research assistant in history at the University of Rhode Island, Kingston, R. I.

in spite of an obvious need for good breechloaders. Here official skepticism was combined with a true lack of desirable and reliable breech-loading designs. A few practical weapons saw service in limited numbers, but without over-all importance.

Many others were presented by inventors to the Navy and War Departments, to be quickly tested and rejected, while still others proved to be as worthless as their designs were weird.

During the late 1850's and early '60's many private inventors tackled the problems of breech-loading cannon, specifically a positive and reliable breech seal in the absence of cartridge cases, and a strong breech mechanism that would not significantly increase the over-all weight of a gun.

In the midst of this activity a few inventors were working on designs for repeating artillery, an idea that, in the absence of an accepted single-shot breechloader, was out of the question to most military men.

To the inventor of 1860 or '61 who chose to attempt to design repeating artillery, the best known concept with which to begin was the principle of multiple chambers, or the revolver. With many inventors trying to adapt a well-known idea to a particular end rather than working on completely new ideas, there is little wonder that the failure rate was high.

In using the principle of the revolving cylinder for artillery, for example, the inventor was faced with three basic problems, over-all weight, the basic strength and safety of the revolver system, and the adaption of the revolver system to achieve an increased volume of firepower.

DEVELOPMENT of revolving cannon goes back at least to James Puckle's Defense patented in England in 1718, and even earlier experimentation probably had been carried on. According to Chinn's "The Machine Gun," a few revolving cannon had been used by the U. S. Navy during the War of 1812, using a flat, horizontal cylinder with the chambers bored from the rim to the axis.

The revolving-cylinder principle, however, had generally been applied to and was probably most suitable for small arms. With this the designers of revolving artillery began, but further work was limited only by the scope of imagination.

One of the first revolving cannon to arrive on the scene during the Civil War was a design by Thomas J. Mayall of Roxbury, Mass. Mayall's first gun was apparently a result of experimentation carried on in the mid-1850's to

eliminate a prime drawback of contemporary revolvers, the fact that a short increase in firepower was canceled out by the considerable time required for loading.

Mayall attempted to achieve semiautomatic swabbing and loading from the front of the cylinder of his revolving cannon at the same time the gun was firing, without taking the piece out of action.

THE Mayall gun used a paper cartridge loaded into the front of the cylinder in the same manner as in hand revolvers, but eliminated the need for separate percussion caps. In his first patent, granted on October 9, 1860, for a gun which underwent considerable change before being submitted to the Government, Mayall described a method of electrical firing of artillery by a rod inserted in the vent of a firing chamber and sparked from a battery.

As far as the writer can discover, this was the earliest use of electrical ignition of firing charges, or for that matter, the first application of electricity to artillery in any form. The idea was evidently successful, for electrical firing, with provision for manual firing by a fuze in emergencies, remained practically unchanged through many refinements and two subsequent patents.

Mayall's final product, described in his patent of May 21, 1861, was an ingenious affair. The carriage itself was mounted on a heavy iron base which in turn sat on wheels with separately mounted recoil buffers at either end. The gun was provided with a hopper for ammunition on the right and immediately ahead of the cylinder, and a rammer, mounted loosely on a crankshaft, was positioned to ram cartridges from the hopper into the cylinder. As the gun recoiled on its carriage in firing, the rammer would travel rearward, load a cartridge into an empty chamber, and be returned by a coil spring. Since the cylinder turned counterclockwise by recoil and a system of gears, a sponger, operating identically to the rammer, was mounted on the left to swab out fired chambers.

With a crew of three, one to load cartridges into the hopper, one to reset the gun with a crank after recoil, and one to fire the gun by manually inserting the electrical firing pin, Mayall claimed the gun to have a rate of fire of twelve rounds a minute, or one shot every five seconds.

The gun finally constructed for tests was a true recoil-operated weapon, but also an unrefined mass of gears and wheels not suited for any practical purpose. The basic design was weak in that the cylinder was mounted only on a center pin without any rigid frame surrounding it. Under sustained firing there is little doubt that the gun would have loosened up very rapidly and opened the gap between chamber and barrel.

The ammunition hopper was placed in an unfortunate position since the flash between barrel and cylinder, accentuated in this weapon, could easily explode all the ammunition in the hopper, to say nothing of that in other chambers of the cylinder. In a test held by the Navy Department in the late summer of 1861 the gun, as suspected, proved itself to be more dangerous to the crew serving it than to any enemy.

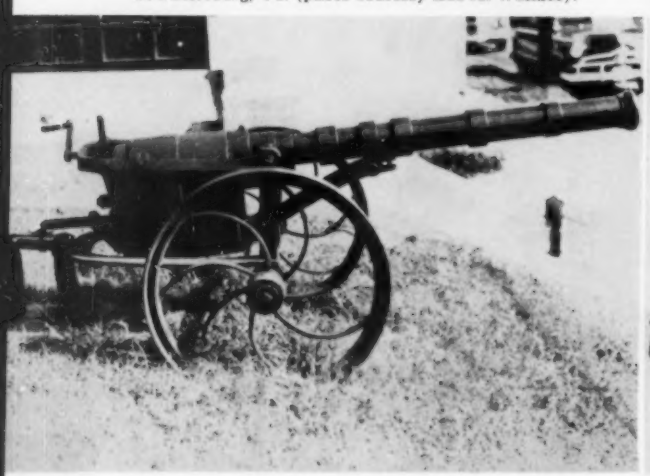
In addition to Mayall's other failings, in designing the autoloading mechanism he had increased weight and bulk out of all proportion to any increase in firepower. Completely useless as a fieldpiece, the weapon was worth little even in fixed positions since, in scaling up, weight would increase much faster than caliber or range.

In spite of the unique recoil operation, the gun was not only immediately rejected and forgotten, but the Government thereafter was not well disposed toward later revolving-cannon designs, some much more suitable for military use.

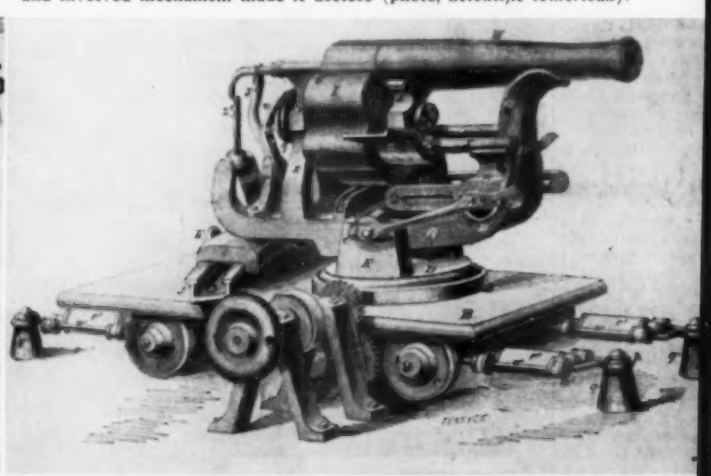
NORTHERN inventors were not alone in the design of revolving cannon and were second to the Confederates in being the first to produce one. In April 1861, Henry Clay Pate of Petersburg, Va., organized a company of cavalry and designed a light revolving cannon. Pate personally ordered two of his guns cast by Tappey & Lumdsen, iron founders of Petersburg, who delivered them in May.

During test firing, one of the guns, for reasons unknown, burst and killed

The Pate-Tappey & Lumdsen revolving cannon, cast at Petersburg, Va. (photo courtesy Lee A. Wallace).



Mayall's revolving gun was a true recoil-operated weapon but weight and involved mechanism made it useless (photo, *Scientific American*).



three of its crew; the other was stored away unused for the remainder of the war.

Chinn's "The Machine Gun" holds that the gun came out of storage to be used in the siege of Petersburg and was later captured and sent to the Ordnance Laboratory at West Point. Lee A. Wallace, Jr., in an article on the gun, says that Capt. Stith Bolling of the 9th Virginia Cavalry bought and used it as a display piece on his lawn.

Whatever its disposition after the war, the gun today reposes on the lawn of the Centre Hill Mansion Museum in Petersburg, and is one of very few revolving cannon to survive.

The Pate-Tappey & Lumdsen is not an advanced design showing a great deal of inventive genius, but rather is a simple application of a revolving cylinder to a cannon. The gun was loaded by hand from the front of the cylinder, the cylinder hand-rotated by a lever at the rear, and the charges fired by percussion primers. The only innovation was a hand crank to push the cylinder forward against the barrel, minimizing gas leakage. The entire gun probably weighed not more than 600 pounds, making it useful as a fieldpiece.

Although it represented little advance in the development of artillery and failed to solve the problem of sustained firepower, the Pate-Tappey & Lumdsen gun, like the Confederate double-barreled field gun now in Atlanta, Ga., is something that is well worth the examination of any student of Civil War artillery.

THE next invention presented to save the Union cause was the design of James A. DeBrame of New York City —and an excellent design it was. DeBrame concentrated on the problems that Mayall apparently ignored, taking into consideration strength of design, over-all weight and bulk, the problem of heat, safety of operation, and, finally, simplicity. In short, only the basic revolving cylinder allied it with Mayall's mass of machinery.

DeBrame's gun was based on a long cylinder, bored through from end to end to be loaded from the rear and mounted in a rigid iron frame which completely covered the lower half.

Unlike other revolving guns, in DeBrame's weapon the bottom chamber of the cylinder was fired, not the top. Thus the firing chamber was completely enclosed in the iron frame, and was not likely to injure the gun crew in case of a burst.

Built into the frame at the rear was a large screw and wrench which, when screwed in, would not only seal the rear of the firing chamber with a plug but would force the cylinder against the barrel. The cylinder was turned and locked in place by hand, and fired by primers.

DeBrame never claimed any specific rate of fire for his gun, but, in spite of his use of hand operations in place of Mayall's machinery, by the virtue of swabbing and loading from the rear of the cylinder DeBrame could probably have closely approached Mayall's twelve rounds a minute.

The purpose of the bored-through cylinder, however, was not ease of loading and rapid fire, but cooling. DeBrame was obsessed with the idea of reducing heat in firing, for he felt, quite rightly, that heat must be overcome in the design of rapid-firing guns.

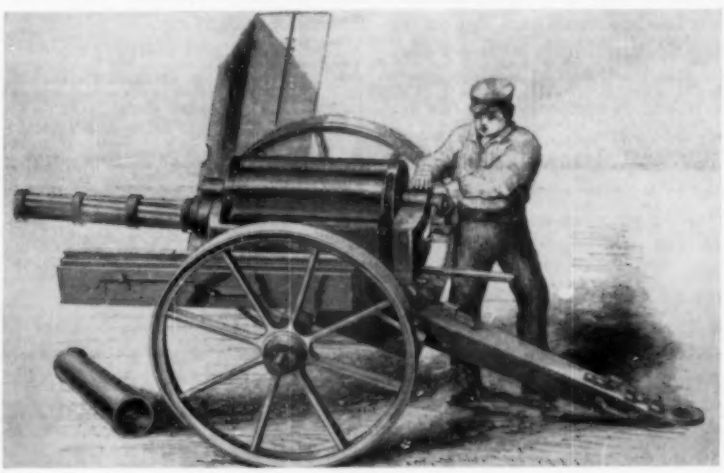
By far the most unique and interesting feature of DeBrame's gun was its barrel, which was not only short, but open to the air to facilitate cooling. DeBrame felt that the usual gun barrel provided more friction and heat to slow the projectile than additional enclosed space for gas pressure to accelerate it.

His own design called for a cage-like tube constructed of steel rods welded to the inside of rings to serve as rifling lands, while what in the ordinary barrell would be grooves was simply open space. Thus, according to DeBrame, his barrel would not only minimize friction, but the light steel rods would not heat up in rapid firing.

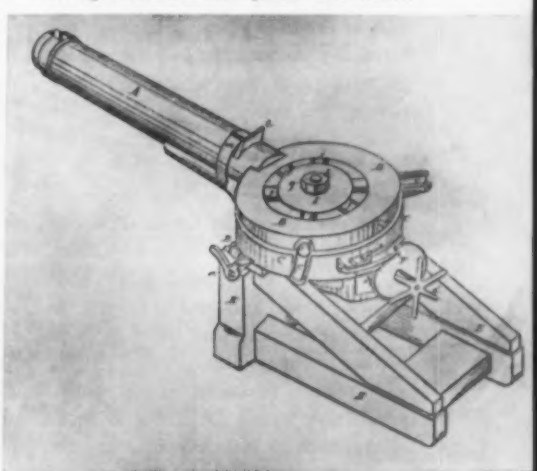
Since the barrel was necessary only to rotate the projectile, it was very short—7 to 11 times the caliber—much less than the usual formula. The cylinder, however, was three or four times the actual length of the loaded charge.

Exhibiting a working model about 1/7th the size of a standard 6-pounder,

DeBrame's revolving cannon with short, open barrel. Tube on ground is barrel cover to prevent escape of gases between rifling rods (photo, *Scientific American*).



The Bernhard Franke cannon arranged revolving chambers like spokes of a wheel.



DeBrame described his gun, barrel, and ideas before the American Institute of New York on June 6, 1861. The meeting, reported in the *Scientific American* of June 22nd, aroused a great deal of interest.

DeBrame had tested the model prior to the meeting, but without witnesses, so a further test was arranged for June 21st with four members of the Institute's Polytechnic Association, to prove or disprove the claim that the open barrel caused no loss of power.

The trial was arranged as a test of penetration, with a member by the name of Dibbon preparing measured charges. Firing at a bale of 1,000 sheets of heavy paper, penetration was found to be significantly greater with the open barrel than with the barrel enclosed by a metal sleeve.

ON a smaller scale, with two Hall carbines, the one fitted with a DeBrame-type barrel provided somewhat greater penetration than one with a standard barrel and issue ammunition.

No test was made of DeBrame's gun against a standard gun of the same caliber with a barrel length equal to DeBrame's barrel and cylinder combined, but the witnesses reported favorably on the gun as a result of the penetration tests. Two recommendations were included, one that the barrel be no longer than eleven times the caliber, and that since the enclosed travel of the projectile in the cylinder was much less than normal for black-powder arms, the best possible quality of powder must be used.

Whether there was a great deal of flash of unburned powder through the barrel is unknown, but had there been, the testing committee would very likely have commented.

DeBrame, young and overconfident, immediately proceeded to apply for a patent. Encouraged by two British artillery officers, in the United States as observers, who had witnessed his trials in June, he constructed a full-scale working model and tried to interest the Ordnance Department office in New York without result.

Successive rejections of his patent application forced DeBrame to make several trips to Washington during the fall, where he personally harassed the Patent Office. Success finally came with the issuance of two consecutive patents on December 24, 1861.

In spite of its apparent excellence, DeBrame was wasting his time in his attempts to have the gun tested by the War or Navy Departments. Chaos prevailed in Washington, and with the War Department under attack by the press, and Secretary Cameron about to be sacked, nothing moved. DeBrame's revolving cannon was apparently never heard from again, and if it was ever either tried or used by the government or a private organization, the writer has found no evidence of it. The open-barrel concept also was forgotten in spite of its intriguing possibilities, never to be revived.

However, DeBrame's gun was not the last to be heard from revolving cannon. On January 14, 1862, a bare three weeks after DeBrame's patent, a patent was issued to Nicholas Taliaferro of Augusta, Ky., for a rather ordinary gun much like the Pate-Tappey & Lumdsen.

Taliaferro's model had a front-loading cylinder, fired the top chamber, and nearly duplicated Pate's threaded center pin for moving the cylinder against the barrel. It thus offered nothing new and provided no advantage over muzzle-loading single-shot guns.

IN June 1862, Thomas J. Campbell of Lincoln, Ill., patented another weapon that appeared to be a ghost of the Mayall gun. While much of Mayall's machinery was eliminated, Campbell retained most of the disadvantages, with a few additional ones thrown in.

Mayall's simultaneous loading, firing, and sponging system was changed slightly, and its operation made manual rather than automatic. The sponger and rammer were connected by joints and cranks to a heavy vertical shaft at the rear of the piece, as was a heavy gear to revolve the cylinder and fire each chamber.

The vertical shaft in turn ended in a huge crank on top of the device at the rear, to be operated by one man. Not to mention his exposed position, any operator would need both feet planted solidly and both hands to move that single crank, considering the fact that every operation needed to load and fire the gun was in some way attached to it.

In every design there must be something new to warrant a patent, and in Campbell's gun it was an "endless belt" to feed, not ammunition, but percussion caps. Pulled by small pins on the cylinder as it revolved, the belt would place a cap over every touchhole, and carry the fired caps to the ground on the other side. Manual priming was unnecessary. As a gesture to safety, the cartridge hopper, in the same dangerous position as Mayall's, was protected by a metal cover.

DURING the summer of 1862 two similar guns were patented, these with flat cylinders having the chambers arranged out from the vertical axis. Invented by Bernhard Franke of New York City and Moses F. Hardy of Seward, N. Y., respectively, and apparently independently, both guns had six chambers arranged like cogs extending beyond the circumference of the cylinder.

After being revolved to the firing position, the entire cylinder would be moved forward so that the extended chamber could be inserted into a chamber seat in the rear of the barrel, gas leakage through an exposed juncture thus being eliminated.

The idea of a separate breech piece to be inserted in a breech seat in the barrel was an ancient one, however, and although both guns offered patentable refinements, neither solved any basic problems or added to the effectiveness of artillery fire.

The Franke and Hardy guns were the last revolving cannon to be designed in the Union during the Civil War. By late 1862 the word had apparently gotten around to inventors that new weapons, and particularly revolving and other repeating artillery such as centrifugal guns, would find no encouragement in Washington.

Since there obviously was no private market for artillery, development of revolving and repeating artillery largely ceased, and the U. S. Army and Navy fought out the war with muzzle-loading single-shot cannon.

Defense Highlights: Monthly Review and Outlook

• **Preparedness vs. the Atomic Test Ban.**—The goals of the American Ordnance Association, presented on page 632 of this issue of ORDNANCE, are in keeping with the motto of the Association since its founding forty-two years ago—"Industrial Preparedness for Peace"—with industrial preparedness in this era understood to be complete and immediate readiness instead of preparation to produce armaments after hostilities begin.

In fact, the hostility of the Communists has never ceased, for whether they threaten with guided missiles or cajole with talks of peaceful coexistence, they continue to expand their world domination and even now are camping in our front yard. This hostility is made more disturbing by the existence of devastating weapons that can be unleashed by the flick of a wrist.

In this situation, until sensible disarmament can be effected, it is more incumbent than ever on the members of the Industry-Ordnance Team to work together toward the goals of this Association for the complete readiness of our armed services. Only by remaining strong and ready can we maintain the present semblance of peace; otherwise this Nation and its allies will be exterminated by a force that openly avows it will dominate the world.

However, we cannot have complete readiness for unlimited or limited war and for our own protection against attack if we continue to hold up progress on our most potent weapon component—the nuclear warhead, both large and small.

We seem to be bemused by the clamor of frightened people and by nebulous concern over what others think of us. Yet such people are not likely to give effective aid should hostility break out into limited or unlimited warfare.

It is absurd on the historical record to believe that any aggressive-minded power would not take full advantage of such a respite as offered by the nuclear test ban. There is a glimmer of a more sensible approach in President Kennedy's announcement that test-ban talks would be delayed and that a final agreement must be reached.

However, this does nothing to prevent our atomic capability from decaying further unless a quick decision is made.

• **Defense Problems and Progress.**—Defense Secretary Robert S. McNamara is meeting frequently with the Joint Chiefs of Staff—a procedure started by former Secretary Gates who was able thereby to make prompt decisions and help clear up some interservice disagreements.

One decision that will continue to flare back at Secretary McNamara will stem from the Joint Air Force-Navy strategic targeting command under Gen. Thomas Power, Commander, Strategic Air Command. Reports indicate that some targets are assigned too many strikes and that much of the target selection is based on sketchy intelligence.

There also remains the standing argument of counterforce (knock out all military targets—if you can find them) versus optimum deterrence directed against industrial and government centers.

Secretary McNamara informed a congressional committee that he is prepared to keep his post for four or possibly eight years at the President's pleasure. He also said that he plans no major changes in Defense organization until he had made a full study.

Deputy Secretary of Defense Gilpatric, who was a member of Senator Symington's Committee on Defense Reorganization (one recommendation—eliminate the service Secretaries) told Congressmen that he agreed with the committee's report but did not favor abolishing any of the services.

• **Nuclear Engine Progress.**—The Aircraft Nuclear Propulsion (ANP) Project suffered a downward slide when the "Eisenhower Budget" reduced funds and recommended only one technical approach. Congressmen, Air Force experts, and AEC engineers objected because neither engine, direct-cycle nor indirect-cycle, had shown superiority.

Much more work is needed in this difficult project, handicapped for many years by indecision and fluctuating funds, before a sensible decision is possible. The new Administration is expected to be more understanding.

Other nuclear-engine projects seem to be adequately funded with $95 million for naval reactors, $30 million for Rover (nuclear rocket), and $20 million for Pluto (nuclear ramjet engine). The latter project suffered a setback when Tory IIA, an experimental vehicle in the Pluto project, broke loose in its railway car and crashed into a concrete blockhouse.

• **New Antitank Weapon.**—Fire it and chuck it! Army Ordnance has made a quantum jump in antitank weapons. The 20-pound bazooka, fired by two soldiers, is being replaced by a rocket that, with its expendable launcher-container weighs only five pounds.

The launching tube, made of part aluminum and part fiber glass, three inches in diameter and twenty-five inches long, serves as a container, telescoping to thirty-eight inches for firing. A graduated sight and percussion-cap firing device are attached to the launcher.

This weapon, the XM72, produces over three times the lethal effect of the bazooka through the use of Octol, a new explosive. In production quantities the cost should be less than $30.

Charles B. Weeks of the Hesse-Eastern Division of Flightex Fabrics, Inc., a past president of the Yankee Post of the A.O.A., was one of the men who conceived and nurtured this new weapon.

• **Progress in Space.**—National Aeronautics and Space Administration plans for 1961 include numerous shots in the Mercury program with, it is hoped, several manned orbital flights launched by Redstone and later by Atlas boosters. A big event will be launching of the first stage of the Saturn superbooster in the fall. Centaur, a booster of intermediate thrust, also is scheduled for tests.

Scientific satellites will be launched to continue studies in space of the radiation belts, electron density, and micrometeorites; an orbiting solar observatory will give more information on sunspot activity and solar radiation.

For these projects and many more, NASA was listed in the recent Administration's budget for $830 million plus $293 million for construction programs and salaries. The three largest items were Saturn, $168 million; lunar and planetary exploration, $103 million; Mercury, $74 million.

• **ASW Helicopter.**—The Navy soon will add a versatile new "weapon system" to its ASW paraphernalia—the HSS-2 all-weather helicopter. The Sikorsky "Hiss-2," powered by twin turbines, is amphibious and its instrumentation and armament give it both search and attack capabilities.

It has automatic devices to shift from forward flight to hover and to control hovering and has passed the 4-hour endurance tests and speed requirements.

In armament tests the helicopter successfully carried and employed all types of ASW weapons designed for use by aircraft. It also can be used for minesweeping or towing.

• **Trailblazer Test Vehicle.**—The Trailblazer, a down-firing reentry test vehicle, typifies the complexity of governmental and industrial relations in space investigations. It is a tool required in Project Defender, the program to investigate all possible means of countering ICBM's, under the direction of the Advanced Research Projects Agency.

The Air Force, at the request of ARPA, has a contract with the Lincoln Laboratory of the Massachusetts Institute of Technology for several phases of Project Defender.

In one phase, Lincoln Laboratory has contracted with Atlantic Research Corporation to supply the rocket ($500,000 for six firings) and arranged for technical direction by the Flight Physics Branch of NASA at Langley, Va., and for firings at NASA's Wallops Island Station.

Incidentally, downward firing reentry rockets were developed and tested previously by the Flight Physics Branch.

To build up the Trailblazer, Atlantic Research is using a 3-component first stage from Thiokol, a Grand Central Rocket Company Lance for the second stage, and a rocket motor from Hercules Powder Company's Alleghany Ballistic Laboratory for the third down-firing stage. The fourth stage, a second and final downfiring rocket, will have a spherical motor developed by NASA.

The most interesting component is the 15-inch-diameter spherical motor, successor to NASA's earlier 5-inch motor, that could be very useful in space studies because of its high strength-weight ratio.

After two stages lift the rocket nose about 200 miles, the other two will drive it down at 25,000 feet a second. The data obtained will further the study of attacking ICBM's and also of nose-cone design and material for our own ballistic missiles.

• **Words of Wisdom.**—John Slezak, former Under Secretary of the Army and a regional vice-president of the Ordnance Association, explained to the first class at West Point how the Industry-Ordnance Team cooperates effectively and patriotically with the armed services.

"The fundamental principle of our way of life," he said, "is that to retain it we must practice it. Our Republic is founded on the proposition that it is a dynamic expression of a living, participating, informed, free people. It is a way of life that belongs to the people, that draws its very lifeblood from popular participation.

"Whatever our national strategy may develop into, for it to be successful in our environment it must include a complete citizen understanding of the problems involved and complete citizen participation in their solution."

• **SAC Air Alert.**—The Air Force Strategic Air Command has started practical air-alert training in an unspecified number of its B-52 heavy bombers. All combat crews are reported to have received air-alert indoctrination and are now taking turns remaining airborne for 24-hour periods, refueling from KC-135 tankers as necessary.

This is not the full-fledged alert recommended by SAC but an operation limited by $350 million—the combined budget for fiscal 1960 and 1961 which permits an increase in space parts and replacements for aircraft and their missiles, allowing approximately one-eighth of our bombers to be on airborne alert.

The crew-training part has skeptics puzzled since for years they have been reading in the press about the arduous life of SAC crews and the long training missions in which they frequently engaged.

• **Expanded Research.**—The Army and Navy have expanded their research efforts, the Army by putting its Office of Ordnance Research under Lieut. Gen. A. C. Trudeau, Chief of Army Research and Development, and the Navy by taking over NASA's hydrodynamic research laboratories at Langley, Va.

The former OOR will supervise all basic research for the Army under the Army Research Office in Washington.

At Langley, the Navy will utilize the high-speed model basin, started by the old National Advisory Committee for Aeronautics to experiment with seaplane hulls, and other facilities.

Here, under the direction of BuShips, David Taylor Model Basin in Washington, the Navy will experiment with vertical-lift "water skimmers," hydrofoils, and underwater-missile configurations.

Disarmament

An Editorial

THE appointment of John J. McCloy and Paul H. Nitze to direct disarmament discussions on behalf of United States is very heartening. Mr. McCloy, distinguished as a former Assistant Secretary of War, High Commissioner of the United States in Germany, and a leading financier, is certainly an objective and realistic thinker.

Mr. Nitze, an intelligent and scholarly diplomat, has served in a variety of wartime agencies and was vice-chairman of the Strategic Bombing Survey. He had much to do with the inauguration of the Marshall Plan and served as chief of the State Department's Policy and Planning Staff.

With Mr. McCloy as principal adviser to the President on disarmament and Mr. Nitze in a similar role but located in the Pentagon, it is certain that there will be close cooperation between the State and Defense Departments as well as the Atomic Energy Commission. Whatever is to be accomplished in this important area can be looked forward to with some assurance of realism.

It must be recognized from our own national experience and from the long and deadly wars of history that man is not peaceful by nature, nor are groups of men or nations. Many countries are seeking openings in the defenses of their neighbors to gain their national goals or to better their share of the earth's bounty.

Armament is one of the effects of this rivalry of nations. There is not and there cannot be a totally disarmed society. This is well known to all statesmen and to all economists of this imperfect world. There is a case for armament, however heavy its burden may be. To make the load as light as a nation can afford is the problem of statesmen.

PRIMARILY, every nation has two functions for military force—stability and security. The former is used to prevent disruption of the state; the latter prevents invasion of the national boundaries. Stability recognizes that humanity requires organization, lest it tend to disorder and chaos.

The gavel of the toastmaster, the club of the policeman, the pistols of the constabulary, the armies and navies of nations are not only symbols of authority but means to prevent societies from disruption.

No organization is safe from the attempts of minorities to gain unfair advantages, if opportunities arise to permit them to strike for their objectives. To stir minorities into action is one of the nefarious schemes of the Communist agents in all nations. The stabilizing forces everywhere must be the greater on this account.

But the greatest requirement for armament arises from the threat of belligerent neighbors against the national borders. This belligerency can arise from many causes—economic, social, and religious. At the present time, the principal threat to this country comes from the Communist goal of world dominion for the Communist nations under Communist control. Until this goal is abandoned, there can be no lessening of our armament preparedness.

This burden is heavy upon the Communists as well as upon all the nations of the non-Communist world. It is the principal cause of the constant and urgent demand for disarmament. World tension is so great that each nation fears to reduce its armament strength until there is some dependable guarantee of equal reduction of the threat from the opposite side. Disarmament is a matter of degree; it can never be total.

THE advent of air power has made the surrounding atmosphere of this planet a channel to all parts of the land and sea, and no such protection can be produced in the air as has been provided on the seas. Armies may now be landed by aircraft and parachute almost anywhere, and powerful weapons may be sent to them through the air channels.

Nations are trying to establish the lifting of their boundaries to the skies and, in some measure, success has been secured.

But another menace has been created by the ballistic missile which is able to penterate all boundaries and strike at great distances within the national borders. The destructive power of atomic and hydrogen bombs, capable of being delivered by missiles upon any target, has taxed the ingenuity of human invention to counter this threat to national saftey and to human life everywhere.

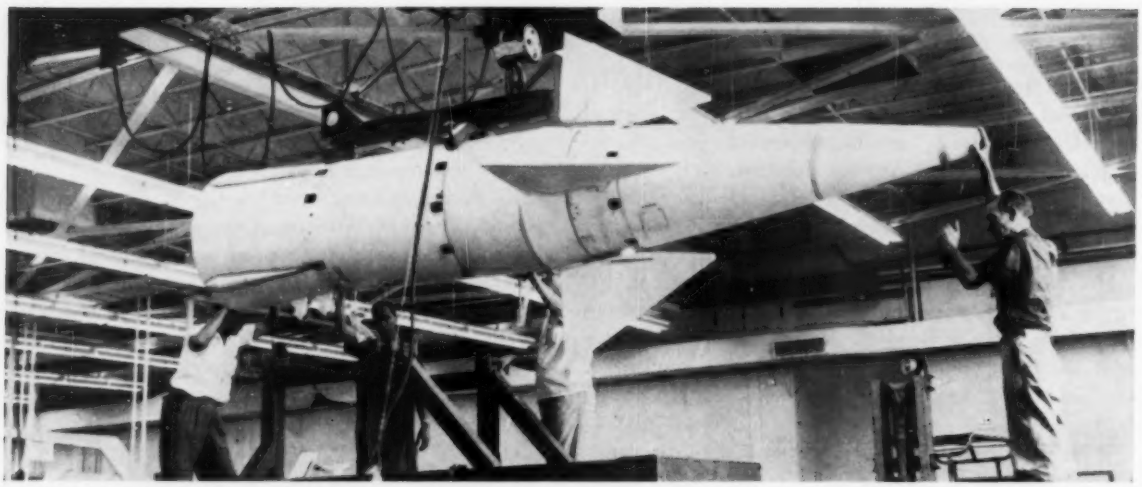
There also is a crying need for better world organization. The disintegration of the world into smaller and smaller nations is a move in the direction of chaos. The Assembly of the United Nations is now but a conglomerate organization for debate, propaganda, indecision, and inaction. Integration into larger and more powerful units, under proper guarantees of liberty and justice, will be a move in the direction of order.

Until greater consolidation is achieved, only stumbling and indecision can be obtained in international affairs. If this inaction, strongly supported by the Communists, is continued until there occurs a clash of modern armament in battle, man's hope of freedom will be lost again for many generations.

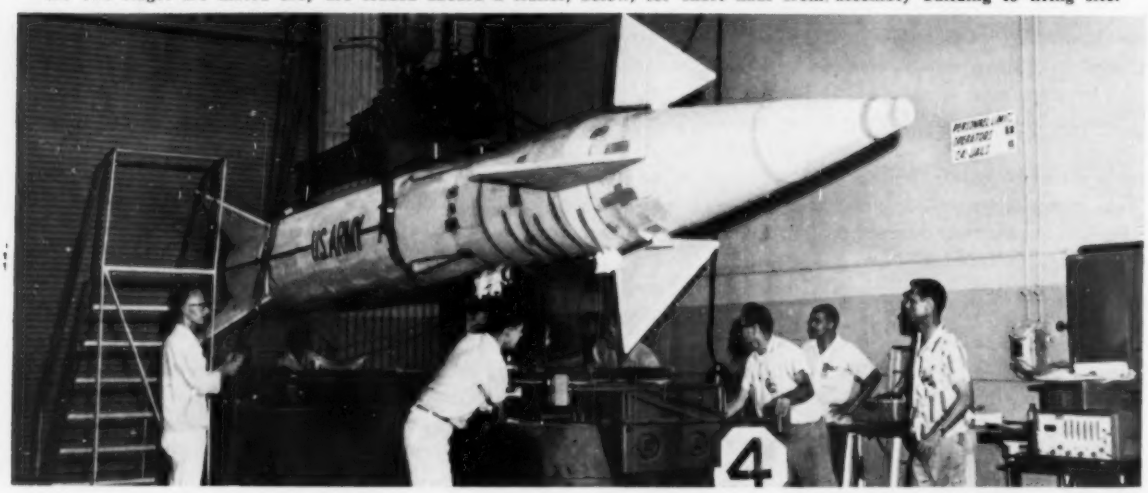
But better world organization and honest cooperation must come before disarmament. Ahead of all else, the tensions fomented by the Communists must be stopped.

The experienced gentlemen who will direct the maneuvers in the disarmament arena on behalf of our country know full well, as do all men of experience and historical background, that excessive armaments are an effect of ill-will—not a cause of it. To say that armaments are responsible for war is equivalent to saying, in the words of Lord Raglan, that a man plays golf because he has a niblick.

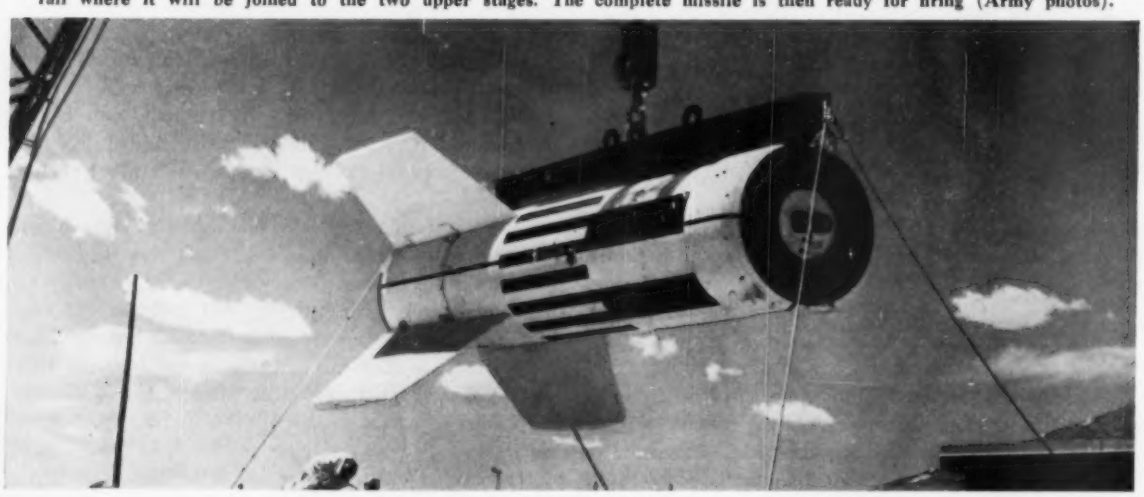
Nike Zeus Gets Ready



The third and final stage of the Nike Zeus antimissile missile, above, is positioned for mating with the second stage. After the two stages are mated they are loaded aboard a trailer, below, for short haul from assembly building to firing site.



At the firing pit, final assembly of the Nike Zeus begins by placing the powerful missile booster, below, on the launch rail where it will be joined to the two upper stages. The complete missile is then ready for firing (Army photos).



ASSOCIATION AFFAIRS

Colonel Graham Is Principal Speaker At Conference Of Rochester Chapter

The Empire Post's Rochester Chapter held one of its most successful meetings on November 16th at the Powers Hotel, Rochester, N. Y. Col. John W. Graham, commanding officer, New York Ordnance District, was the main speaker at the all-day conference devoted to procurement techniques. His topic was "Today's Progress in Army Missiles."

Colonel Graham pointed out that extraordinary methods must be employed to assure a reasonable lifetime for any weapon system before it is overtaken by obsolescence. "History abounds with examples of the unending struggle between the offense and the defense," he said. "The appearance of a new or revolutionary weapon gives its possessor an advantage measured in time by the span his adversary requires to develop a defense against it or to develop another weapon capable of overwhelming his defenses." Nike Zeus was singled out by Colonel Graham as the only antimissile weapon system that can be put into the field in a reasonable time.

"The old problem of lead time gives the Zeus an advantage over any other similar defense system designed to counter the same threat," he said. "There is also a growth potential inherent in the Zeus system that will permit substantial improvement in its performance capabilities. The Army believes that Nike Zeus will be capable of intercepting enemy ICBM's that might be launched against any area it defends.

"If carried through to development, Zeus could protect a large segment of the country's war industry potential, safeguard the lives of millions of people, and protect a good part of the retaliatory capability. Defense of that order of magnitude could help tip the balance of power in our favor."

In conjunction with the meeting, representatives of industry and the Army, Navy, and Air Force displayed exhibits of items procured in the upstate New York area from A.O.A. member-contractors. Experienced personnel from the armed forces procurement services were on hand to assist business firms interested in defense contracting. Also on display was an operational model of the Nike Ajax missile. Springfield Armory contributed an interesting exhibit featuring the Army's M14 rifle which attracted much attention.

The all-day meeting opened with a discussion of services available to both small and large contractors in the procurement of defense matériel. Members of this panel were Comdr. Stanley E. Wagenhals, Bureau of Naval Weapons, Rochester, N. Y.; Maj. Harold F. Ehrlich, chief of the Contract Division, Rochester Air Procurement District; and Colonel Graham.

Other speakers and their topics were: Francis I. Foose, chief auditor, U. S. Navy Audit Office, Rochester, "New Cost and Price Principles of Procurement Regulations"; Edgar S. Moser, manager of security, Stromberg-Carlson Division, General Dynamics Corporation, "Plant Security in Classified Military Contracts"; J. Foster Thompson, law firm of Thompson & Hayes, Rochester, "Pitfalls and Safeguards in Government Contract Provisions."

Also, Henry Kohlmeier, assistant chief, Quality Control Division, Rochester Air Procurement District, "Evaluation of Air Force Quality Control in Industry"; Richard C. Scott, assistant vice-president, Genesee Valley-Union Trust Company, "Financing Government Contracts"; and F. M. Emerson Holmes, patent counsel, Eastman Kodak Company, "Government's Right to Inventions and Proprietary Data."

John D. Smith, Rochester regional manager, New York State Department of Commerce, was moderator for the conference.

Officers of the Rochester Chapter are: chairman, J. Westcott Wright, Bausch & Lomb, Inc.; vice-chairman, James P. Cooper, General Railway Signal Company; treasurer, Raymond M. Biehler, Rochester Institute of Technology; and secretary, Maj. John F. Wilbur, Rochester Regional Office, New York Ordnance District.

In charge of the program were Mr. Thompson, chairman; Thomas H. Robinson, Eastman Kodak Company; and Edwin G. Nixon, Francis W. DeSerio, and Harry F. Rapp, Rochester Regional Office, New York Ordnance District.

Col. John W. Graham, commanding officer, New York Ordnance District, left, principal speaker at meeting of the Rochester Chapter, chats with John D. Smith, New York State Department of Commerce, and Maj. Harold F. Erlich, chief of the Contract Division, Rochester Air Procurement District, right.

Los Angeles Post Holds Luncheon Meeting At Jet Propulsion Laboratory

The third event of the season for the Los Angeles Post was a luncheon meeting and visit to the California Institute of Technology Jet Propulsion Laboratory in Pasadena, Calif., on November 15th.

At the luncheon the host for the afternoon, Dr. William H. Pickering, director of the laboratory and a director of the Los Angeles Post, talked to the members on the role of JPL in the space age. He explained why the laboratory was founded and described some of the developments now in progress to advance knowledge in the conquest of space.

During the visit to the laboratory the members witnessed many of the technological developments that had been described by Dr. Pickering. The quota of 280 for this affair was oversubscribed as usual so that attendance had to be decided by drawing lots.

Brig. Gen. C. W. Clark Speaks Before Cumberland Valley Post At Letterkenny

An illustrated report on the Ordnance Corps' latest products by Brig. Gen. C. W. Clark, Assistant Chief of Ordnance for Research and Development, highlighted the annual dinner meeting of the Cumberland Valley Post on November 30th at the Officers' Club at Letterkenny Ordnance Depot, Chambersburg, Pa.

Approximately eighty members and guests of the Post attended the affair which included, in addition to the speech by General Clark, a tour of the depot and a dinner at the executive dining room at Letterkenny.

Attending Cumberland Valley Post meeting are, l. to r.: Col. Travis Brown, commanding the New Cumberland, Pa., General Depot; W. H. Strauss, Post president; Brig. Gen. C. W. Clark, Assistant Chief of Ordnance, guest speaker; Brig. Gen. D. E. Breakfield, Commanding General, Letterkenny Ordnance Depot; Rear Adm. J. B. Ricketts, commanding the Naval Supply Depot, Mechanicsburg, Pa.; and Col. C. E. Collins, Jr., commanding the Major Item Supply Management Agency at Letterkenny.

In discussing the things research and development personnel are looking for in new weapons, General Clark said:

"We seek additional firepower, which includes higher rates of fire and high-damage-causing capabilities. Better devices are needed to locate, identify, and 'home-in' on enemy targets. Our transportation systems must be improved. The increased need for lighter weapons prompted and accelerated development and application of lighter-weight and higher-strength metals. We must continue such developments.

"Much is being done to provide lighter-weight guns of the same firepower and thus enhance their mobility. Through various applications of the cold-working principle, we get the most out of the new steels of ever-increasing strength. The addition of rockets and missiles to our offensive potential has further strengthened our mobile firepower since these weapons are lighter, have greater range, and can be handled more easily.

"The tacticians envision great depth and fluidity in any future battlefield where atomic power may be brought to bear. We must logically anticipate the need to disperse troops and bases and exploit the capability to strike quickly.

"Our troops must react faster, cover more ground, protect larger areas, move and regroup more rapidly than ever before. Tactical success can be achieved only by greater speed of movement over all types of terrain. Of prime importance to our continental defense, as well as defense of forces in the field, is the Ordnance mission in the development of air- and missile-defense weapon systems."

General Clark concluded his presentation by saying: "While we are now beginning to use these splendid weapons and equipment, we are at the same time engaged in the research and development of even newer and more powerful weapons. Our objective to be second to none calls for no lessening of the effort."

Among the many new products of the Ordnance Corps discussed and illustrated by General Clark were the following: the M14 rifle, the M60 machine gun, the Claymore antipersonnel mine, the 40-mm. grenade launcher, the 90-mm. M67 recoilless rifle, the 175-mm. self-propelled gun, the hand-grenade fuze, the armored personnel carrier, the "Goer," a 15-ton cargo truck, and the Nike Zeus missile designed to attack incoming ballistic missiles.

Brig. Gen. D. E. Breakefield, Commanding General of Letterkenny Ordnance Depot, was host for the affair. Among those attending the dinner meeting were Rear Adm. J. B. Ricketts, Commanding Officer, U. S. Naval Supply Depot, Mechanicsburg; Col. Travis Brown, Commanding Officer, New Cumberland General Depot, New Cumberland; Col. Charles E. Collins, Jr., Commanding Officer, Major Item Supply Management Agency, Letterkenny Ordnance Depot; and Lieut. Col. Harry Craig, Technical Liaison Office, Office of the Chief of Army Ordnance, Washington, D. C. William Strauss, president of the Cumberland Valley Post of the A.O.A., presided.

General Hinrichs Addresses Monthly Luncheon Meeting Of The Washington Post

Lieut. Gen. John H. Hinrichs, Chief of Army Ordnance, was the guest speaker at the Washington Post monthly luncheon on Thursday, January 19th. After introducing the head-table guests, the presiding officer, M. C. Richmond, Post president, gave a friendly and interesting introduction of the guest speaker, reminding the audience of the military background of several generations of the Hinrichs family.

The theme of the general's talk was "Meeting the Challenge in the Management of Ordnance Business." He noted that this was a challenge not only to military men but also to industrialists. As the basic problem he cited that "unless over-all defense spending increases, the only way open to us to buy more of the new weapons is to reduce the cost of development and production."

He made some basic observations noting that a weapons system must be related to the performance expected of it, it must satisfy military characteristics, and it must be in the hands of the user at the time and in the quantities he considers essential.

He gave evidence of the growing complexity of management by showing a 2-page contract from 1818 for an Army rifle and then the massive volume which was the contract for the new M14 rifle.

General Hinrichs took issue with cost control as the ultimate goal in all cases and explained that costs reduced by good engineering practice were worthwhile but that some costs that had been reduced after inadequate study made the end item more expensive in the long run.

He closed his talk by stating that "industry can be of great assistance to the defense establishment in painstaking analysis of all components. We are mutually concerned with the country's survival and well-being. In the light of that stake, this is a challenge that demands our best—nothing else will do."

Other head-table guests were: Maj. Gen. H. F. Bigelow, Deputy Chief of Army Ordnance; Rear Adm. P. D. Stroop, Chief, Bureau of Naval Weapons; Hon. James E. VanZandt, 20th District of Pennsylvania; Maj. Gen. Marvin C. Demler, Director of Aero-Space Systems; Maj. Gen. Oscar Senter, Assistant Deputy Chief, Development, U.S.A.F. Headquarters; Rear Adm. R. K. James, Chief, Navy Bureau of Ships; Rear Adm. William A. Schoech, Deputy Chief, Bureau of Naval Weapons; Rear Adm. Edward A. Ruckner, Assistant Chief, Bureau of Naval Weapons; and William E. Haines, first vice-president, Washington Post.

A. J. Langhammer Receives Award For Service In A.O.A. Powder Metallurgy Section

A. J. Langhammer, retiring chairman of the A.O.A. Powder Metallurgy Section, Materials Division, was the recipient on December 13th of the American Ordnance Association's Achievement Award in recognition of his many years of spectacular service to the organization. The presentation was made at a dinner that evening at the Army-Navy Club, Washington, D. C., attended by many of his friends from industry and government.

Mr. Langhammer reflected on his experiences and pleasures in organizing and developing this most dynamic Technical Section, and turned over the chairmanship to Norman L. Gebhart, general manager, Delco-Moraine Division, General Motors Corporation, confident in the knowledge that the activities of the Section will continue to lend strong technical support through the many Defense Department engineers who have learned to use it in recent years.

On the following day, the Section met at the Naval Ordnance Laboratory, Silver Spring, Md., to hear several papers on the powder metallurgy of zinc, lead, aluminum, and brass. Magnetic structures using powder metallurgy were also described as well as the status of powder-metallurgy applications in ordnance.

The next planned activity of the Section will be a visit to plants in the area of Cleveland, Ohio, on April 27th during which government engineers will have the opportunity to see commercial powder-metallurgy production at first hand.

A. W. Gilmer Is Awarded Army Medal At Meeting Of Philadelphia Post

The U. S. Army awarded its Outstanding Civilian Service Medal to Albert W. Gilmer, a member of Barnes, Dechert, Price, Myers & Rhoads, and assistant counsel of the American Ordnance Association, at the January 18th meeting of the Philadelphia Post.

The presentation was made by Maj. Gen. Gunnar C. Carlson, Assistant Chief of Ordnance, United States Army. Colonel Gilmer was cited for his many years of service as civilian chief of the Philadelphia Ordnance District. He is a former president of the Philadelphia Post and an active participant in all the affairs of that organization.

Some 250 members of the Post attended the meeting, presided over by Post President George Burnham, IV, U. S. Steel Corporation, Philadelphia, Pa. The meeting, held at the Jenkintown Plant of the Standard Pressed Steel Company, was preceded by a tour of the plant where the group observed the high quality of the innumerable fastening devices for which this company is renowned.

Following the gracious acceptance of the award by Colonel Gilmer, the principal address of the day was delivered by H. Thomas Hallowell, Jr., president of Standard Pressed Steel. Mr. Hallowell emphasized the necessity for bringing Government specifications and procurement procedures up to date to assure that the Government received items of required quality and not merely those of low price.

Following the meeting, Mr. Hallowell and his staff were hosts at a well-attended reception.

At Philadelphia Post meeting are, l. to r.: Weber deVore, A.O.A. Council representative; C. Jared Ingersoll, Post director; Col. L. A. Codd, A.O.A. executive vice-president; Albert W. Gilmer, Post director and recipient of Army award; H. T. Hallowell, Jr., president, Standard Pressed Steel, guest speaker; Maj. Gen. W. K. Ghormley, head, Ordnance Special Weapons-Ammunition Command; Maj. Gen. G. C. Carlson, Assistant Chief of Ordnance; George Burnham, IV, Post president.

China Lake Post Breaks Its Attendance Record At Naval Ordnance Test Station

The China Lake Post broke records with a turnout of almost 200 members and guests for its dinner meeting on Thursday, December 15th at the Naval Ordnance Test Station Open Mess. The guest speaker was Brig. Gen. John A. Dunning, Commander, 831st Air Division, George Air Force Base, Calif.

The presiding officer, Haskell G. Wilson, Post president, introduced the Post's officers and directors and Capt. W. W. Hollister, Commanding Officer, NOTS, who were at the speakers' table.

General Dunning spoke on "The Tactical Air Command in Limited War." As background he carefully explained the

Among those at China Lake Post meeting are, left to right: Haskell G. Wilson, Post president; Brig. Gen. John A. Dunning, Commander 831st Air Division, George Air Force Base; and Capt. W. W. Hollister, Commander of the Naval Ordnance Test Station, China Lake, Calif., where the meeting was held.

concept of deterrence summarizing it as "a collective state of mind of the Soviet leaders who must be impressed with the real capabilities of this nation, in conjunction with our allies, and the realization that, if attacked, we have the will and determination to use our power."

He then discussed the Air Force position on counterforce, the need to destroy an enemy's military bases and missile sites, and cited diversity of force, rapid reaction, and devastating firepower as the qualities of the Air Force strength that ensures deterrence.

"Tactical Air Command forces," he said, "are certainly not restricted exclusively to limited war. The fighters possessed by the Tactical Air Command have the capability and the versatility to use many types of weapons from machine-gun bullets to nuclear devices. These forces in overseas areas are capable of, and have the responsibility for, participation in a general war if the need should arise.

Some of the forces located in the United States are required to supplement the overseas commands in their general-war posture. This is accomplished by continuous rotation of various units into the NATO area and the Pacific area."

After outlining the variations possible in the composition of TAC forces and the worldwide exercises they conduct, General Dunning told of the need for more versatile armaments and aircraft.

"Small-war capability of the Air Force," he concluded, "is contained within its general-war forces, and its speed of application anywhere in the world is of cardinal importance in preventing or quelling dangerous situations. TAC forces can get there and get there fast with augmentation of theater general-war forces or small-war strike forces."

Admiral Raborn Hails Polaris System At San Francisco Post Fall Meeting

A sellout attendance of 500 at the San Francisco Post fall dinner meeting on November 10th heard Vice Adm. William F. Raborn, Jr., hail the Polaris weapon system now "somewhere in the Atlantic" as a strong persuasive force for peace—like a bullet in a pointed rifle.

Post President E. Finley Carter, Director of Stanford Research Institute, called on Col. H. H. Heuer, Sixth U. S. Army Chaplain, for the invocation and then asked Willis M. Hawkins, Jr., to introduce the speaker.

Mr. Hawkins, assistant general manager of Lockheed Missiles and Space Division, prime contractor for the Polaris missile, described the rugged drive of Admiral Raborn which pushed the Polaris system to operational readiness three years ahead of schedule. He lauded the admiral, as director of the Navy's Special Projects Office, for convincing the Navy and the Congress on what must be done and in enlisting support and a sense of urgency right down the line.

After telling his audience at the Fairmont Hotel there was no "ultimate weapon" and that the American Ordnance Association had long demonstrated its concern with the tools of national defense, Admiral Raborn said:

"A frame of mind is essential for peace. Are you going to pay the price for what you think is right? Are you going to pay out of your pocketbook in terms of peace? I think the American Ordnance Association should be critical of where your money is spent. You should exercise your prerogative in letting people who make the decisions know what you think. Our country deserves the best we are able to produce. Our sense of sacrifice needs to be much greater than what it is today. We need this country to be stirred up to be critical. Let your Congressman know what you think!"

Referring to the concept of putting the armed forces into one uniform he said:

"I think this is a bunch of you-know-what. Can you imagine selling this (the Polaris system) to people who know nothing about the ocean and who have partisan feelings elsewhere? We need the separate services with their own ideas."

He said the Navy-industry-produced Polaris had achieved more success than any missile in any service at any time.

"You as American citizens can be very proud of this dedicated development team," he said. "We have capitalized on the wonderful skills of American private industry . . . The Polaris has proved 75 per cent reliable and we are heading for 85 per cent."

Five nuclear fleet ballistic missile submarines are in the water and three have been commissioned. The U.S.S. PATRICK HENRY will follow the U.S.S. GEORGE WASHINGTON to station at sea. These nuclear-powered subs can cruise to the limit of their highly trained crews' endurance. And communications with these submarines, he said pointedly, are effective and are established by very-low-frequency stations placed to girdle the globe with Navy messages.

Urging more such nuclear missile submersibles, he said that no one knows how to wipe out a large force of such vessels at sea; if he does "let him join the Navy—we are looking for him." He foresaw no Soviet surprise attack if America had thirty or forty such craft. Each is a very strong persuasive force.

"With this deterrent force on station, we can use it promptly—or with deliberation," he said.

"Have you tried to live in a 30-minute time span—the time it takes an intercontinental missile to get where it's going? In thirty minutes what will you use to save your skin? If you want to live in monuments in the ground, the Soviets will know about them, and these monuments can be hit. But our subs in three oceans are not tied down. The unseen sub is not provocative, but it is available—and uncomfortable."

The most expensive weapon in the world, Admiral Raborn said, is the second-best weapon. If this country can't

afford the best weapon, then it won't be a country very long. He said others talk about cheaper weapons, but they haven't produced them yet. The Polaris sub costs about $100 million—about the cost of any missile base. But by submerging, the submarine can get many times the "hardness" of a "hard" missile base. "In the long run," he said, "I think this is the most inexpensive weapon for peace you can get."

"Today we fired our first 1,500-nautical-mile (Polaris A-2) missile. We are proud of Aerojet-General Corporation which made the first- and second-stage motors. A 2,500-nautical-mile Polaris missile now is under way. I am confident our solid-state propellant contractors can crash through on this."

In a question-and-answer period the admiral referred to the recently announced Polaris station in Scotland not as a proposed base but as a place for maintenance and crew changes to save time and money—like a lot of other things we have overseas. If we have enough subs we won't need such places, he said.

Admiral Raborn believed America is considerably ahead of the Russians in nuclear submarines and small guided missiles.

Our conventional submarines are very useful weapons carrying a big bang. Older nuclear submarines will not be converted to missile subs; it's cheaper to build such from the keel up—and meanwhile they have such important uses as killer subs.

The admiral made it clear there were jobs the aircraft could do best in the fleet and said it was up to every commander to use the weapon best suited for the job.

The Post board of directors passed a resolution of appreciation for services rendered by the former secretary-treasurer, Col. L. H. Harrison, who resigned because of illness.

At the head table were Lieut. Col. William M. Doyle, Commanding Officer, San Francisco Ordnance District, acting Post secretary-treasurer; Stanley Hiller, Jr., president, Hiller Aircraft Corporation; Norman Sutherland, president, Pacific Gas & Electric Company; William E. Waste, executive vice-president, Bechtel Corporation; Walter J. Matham, vice-president, Westinghouse Electric Corporation; Vice Adm. F. N. Kivette, Commander, Western Sea Frontier, U. S. Naval Defense Forces, Eastern Pacific and Pacific Reserve Fleet; Mr. Hawkins; Vice Adm. Raborn; Mr. Carter.

Also, Maj. Gen. G. C. Mudgett, Deputy Commanding General, Sixth U. S. Army; Elmer R. Peterson, vice-president, Standard Oil Company of California; Jack L. Ashby, president, Kaiser Steel Corporation; Col. John M. Stark, U.S.A. (Ret); William E. Hoard, division manager, Western Gear Corporation, and Chaplain Heuer.

Surface Preservation Section Meets At El Paso And White Sands Range

The Surface Preservation Section, Production Techniques Division, met for two days in early November at El Paso, Tex., and the White Sands Missile Range, N. Mex., to study problems of the corrosion of guided missiles.

Approximately fifty industrial experts and Government consultants met at the call of Section Chairman Max B. Roosa, Parker Rust Proof Company, Detroit, Mich. Col. Henry N. Marsh, vice-president in charge of A.O.A. Technical Divisions, greeted the group.

Col. J. M. Gruitch, ACF Industries, Inc., New York, N. Y., chairman of the Production Techniques Division, discussed the importance of contributions to the Government by the Section in shortening development times in new weapons and equipment.

Mr. Roosa was awarded the Association's Bronze Medallion for his outstanding service as chairman of the Section. Mr. Roosa is retiring as chairman and will assume the position of chairman emeritus.

The new chairman is Myron B. Diggin, Hanson-Van Winkle-Munning Company, Matawan, N. J., the former deputy chairman. Dr. Richard B. Saltonstall, Udylite Corporation, Detroit, Mich., is the new Section secretary succeeding E. J. Kubis, Wyandotte Chemicals Corporation, Wyandotte, Mich.

H. K. DeLong, Dow Metal Products Company, Los Angeles, Calif., discussed the protection of magnesium alloys by immersion deposit of tin and tin compounds.

In discussing "New Demands for Improved Protective Systems," A. Gallaccio, Frankford Arsenal, Philadelphia, Pa., emphasized the need for proper selection of materials and insulation to prevent corrosion and fungus deterioration. In further discussion of fungus growth in electronic equipment, Sidney H. Ross, also of Frankford Arsenal, recommended the use of nonhydroscopic materials while avoiding materials such as linens, cellulose acetates, wood, leather, and others.

A review of the problems encountered in finishing magnesium for Ordnance equipment was made by Harry L. Ammlung, Aberdeen Proving Ground, Md. In discussing the studies of corrosion at Aberdeen, Mr. Ammlung particularly noted the difficulty in obtaining reproducible results with stannate coatings.

A joint dinner meeting was held with the Rio Grande Post of the Association on the evening of November 1st. Chris P. Fox, State National Bank, El Paso, Tex., as master of ceremonies introduced the principal speaker of the evening, Brig. Gen. O. E. Hurlbut, Commanding General, Ordnance Weapons Command, Rock Island Arsenal, Ill., who used both movies and actual equipment to illustrate his talk, "Modern Weapons for the Foot Soldier."

The following day, Brig. Gen. John G. Shinkle, Commander of WSMR, welcomed the group to the range where the preservation experts were able to review problems of the Army's series of missiles and rockets.

At White Sands meeting are, left to right: Col. J. M. Gruitch, chairman, Production Techniques Division; Col. Henry N. Marsh, A.O.A. vice-president; M. B. Diggin, chairman, Surface Preservation Section; Max B. Roosa, retiring chairman; Brig. Gen. J. G. Shinkle, commanding WSMR; and Henry Handler, OCO, Washington, D. C.

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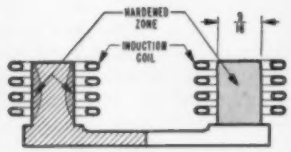

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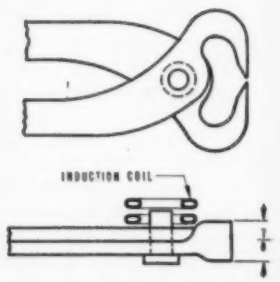

The ends of high-strength steel rivets are selectively heated to 1700° F for hot upsetting. Design of coil permits movement of upsetting tool through the coil.

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Steel For Guns Is Discussion Topic At Meeting Of The Gun Tube Section

Steel for the U. S. Army's newest guns was the subject of discussion at Watervliet Arsenal on January 18th when a score of industry and Government metals specialists gathered for the semiannual meeting of the Gun Tube Section of the A.O.A. Artillery Division.

A. R. Metzger of Bethlehem Steel Company, Section chairman, presided at the morning session which was devoted to an exchange of information on late developments in tube manufacture and to valuable discussions of testing problems and techniques.

Highlight of the afternoon session was the presentation of a technical paper on the vacuum degassing of steel for large forgings by M. V. Herasimchuk, metallurgical engineer on the staff of the vice-president, Steel Division, Bethlehem Steel Company.

Among the organizations represented were: Bethlehem Steel Company, Cabot Corporation, Hughes Tool Company, Midvale-Heppenstall Company, Baldwin-Lima-Hamilton Corporation, Doehler-Jarvis, National Tube Division of U. S. Steel Corporation, Leesona Corporation, the Bureau of Naval Weapons, and Watervliet Arsenal, Watervliet, N. Y.; Watertown Arsenal, Watertown, Mass.; and Frankford Arsenal, Philadelphia, Pa.

Members of the Gun Tube Section, A.O.A. Artillery Division, during meeting at Watervliet Arsenal, Watervliet, N. Y., for discussion of ordnance metallurgy.

Special Value Engineering Committee Holds Initial Meeting At Washington

The Special Committee on Value Engineering held its initial meeting on January 12, 1961, in Washington, D. C. W. M. Gourley, Philco Corporation, Philadelphia, Pa., the Committee chairman, presided over the twenty-seven members and guests present.

The transition of this Committee from its position in the Underwater Ordnance Division to a Committee working Associationwide was reviewed by Maj. Gen. E. P. Mechling, A.O.A. staff director for technical operations. Mr. Gourley then explained the organization of the A.O.A and the position of the Special Committee on Value Engineering within the organization.

Speaking on "The Need for Value Engineering in Military Procurement," W. R. Feichtinger, of the Navy's Bureau of Naval Weapons, explained the Navy's position regarding value engineering. He discussed and illustrated the effect of such engineering upon the defense effort, which he also compared with the national economic situation.

Following luncheon, Col. H. C. Thayer, A.O.A. staff director for public information, discussed the over-all A.O.A. organization and activities, and a talk on "Value Engineering—Industry's New Approach to More Efficient Product Design," was given by L. J. Marcon of Philco Corporation. Mr. Marcon discussed the application of value engineering techniques in research, design, development, and production. Using illustrations, he pointed out the difficulties of the designer in obtaining required performance, reliability, and producibility.

The Committee agreed to the organization of three subcommittees—Motivation, Education, and Technical. J. H. Martin, General Electric Company, Pittsfield, Mass., was nominated chairman of the Education Subcommittee.

C. C. Van Vechten, Thompson Ramo Wooldridge Inc., Cleveland, Ohio, was nominated as deputy chairman, and Guy Pierce, Jr., of Philco Corporation, was nominated secretary of the Committee. Members present indicated interest in assignment to the subcommittees.

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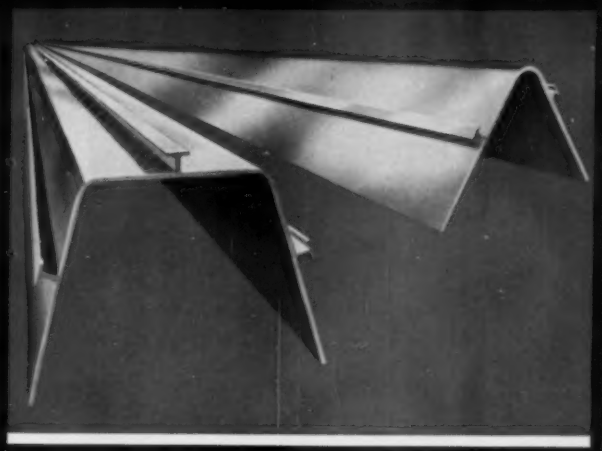
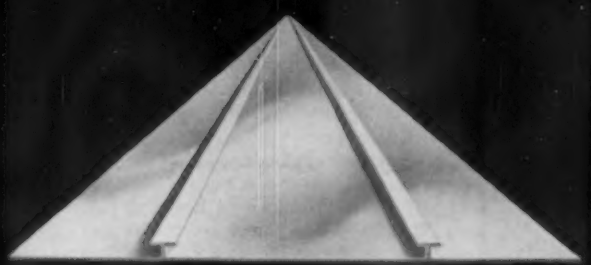
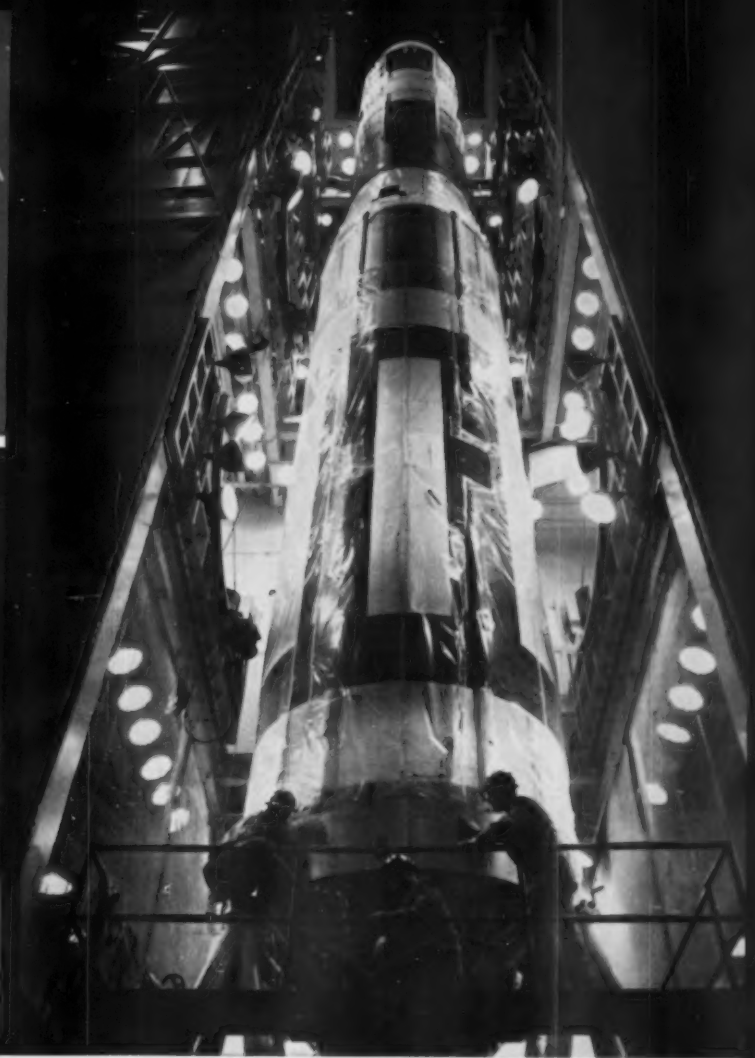




These giant panels are extruded in U-shape with three stiffening ribs, or V-shape with two (top photo) . . . then flattened to close tolerances (lower photo).



The Martin Company photo

DOW EXTRUDES GIANT 34"-WIDE ALUMINUM PANELS FOR TITAN

At Dow's Madison, Illinois, plant, a huge 13,200-ton press extrudes big aluminum panels with integral stiffeners for the Air Force Titan missile. The panels are so wide—34 inches—that they must be extruded with a "U" or "V" cross-section, then flattened and straightened. Panels with three stiffeners get the U-shape; with two stiffeners, the V-shape.

These aluminum 2014 alloy panels are flattened in Dow's contour-correction equipment to close tolerances, then straightened in a 1,000-ton stretcher.

The Dow Metal Products Company's years of large-extrusion experience include production of big parts for aircraft and ordnance equipment, as well as for missiles. Dow's Madison plant is in high-volume production of many different extruded shapes and sizes, in a wide range of aluminum alloys . . . including extrusions with circumscribing circle sizes up to 30 inches, and as long as 80 feet. For information, write The Dow Metal Products Company, Midland, Michigan, Merchandising Dept. 1102DF3.

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The Committee discussed a statement of mission, which was adopted as follows:

"The Special Committee for Value Engineering will be concerned with the general application of normal techniques for the analysis of business, production, and engineering problems of the military establishment with the objective of providing the most effective and economical material and services, and with the further responsibility of supplying specialized consultation, advice, and assistance to the other Divisions and to the military establishment."

A meeting of the Steering Committee was proposed in approximately two months, with a meeting of the full Committee scheduled approximately two months later.

A.O.A. Pyrotechnics Section Holds Annual Meeting At Lockheed Space Facility

The fourth annual meeting of the Military Pyrotechnics Section of the Bomb, Warhead and Artillery Ammunition Division was held at the Lockheed Missiles Space Division's facility at Sunnyvale, Calif., in November. The meeting was attended by more than fifty members and consultants of the Section, together with their guests.

The theme was "pyrotechnics in the Space Age," and the technical papers and discussions stressed the important role which pyrochemical devices and accessories play in providing power sources, spotting charges, timing devices, and other vital components in today's steps in the conquest of outer space as well as in vehicles and weapons for the national defense.

Following the welcoming addresses by Lockheed officials, it was regretfully announced that the Chairman, Dr. Herbert Ellern, Universal Match Corporation, St. Louis, Mo., was unable to attend due to illness. I. B. Gluckman, Lockheed Aircraft Corporation, Sunnyvale, Calif., and Lincoln Love, Perry Plastics, Inc., Erie, Pa., agreed to be cochairmen for the meeting.

Dr. Ellern's opening comments were read for him by Secretary E. R. Lake, Universal Match Corporation, together with the statement of the mission of the American Ordnance Association. Six technical papers were then presented during the remainder of the day.

At 6:30 p.m. Lockheed was host at a reception immediately followed by a fine dinner under the auspices of six company sponsors.

The following morning three more technical papers were presented prior to the opening of the business meeting at 11:00 a.m. At this meeting the secretary announced to the members that Dr. Ellern had resigned as chairman, and the Division chairman, R. L. Telford, Mason & Hanger-Silas Mason Company, New York City, on recommendation of the retiring Section chairman, appointed Dr. R. W. Evans, Denver Research Institute, Denver, Colo., to fill the post, with Mr. Love as deputy chairman for the next two calendar years.

Dr. Evans expressed the Section's thanks to Dr. Ellern for his active contributions in getting the Section into full swing. In addition, he expressed everyone's thanks to the host, Lockheed Aircraft Corporation. At the close of the business meeting Frank LaHaye, president of McCormick Selph Associates, offered an invitation to visit his facility at Hollister the following day. Following lunch, a plant tour was made of the Palo Alto research facilities of Lockheed.

The following papers were read and discussed during the technical sessions: "Pyrotechnics in Space Application," Mr. Gluckman, Lockheed Missile and Space Division (LMSD); "Radiation Environments and Problems in Space," Dr. J. C. Lee, LMSD; "Basics of Reliability Control," R. A. Blais, LMSD; "Pyrotechnics and Spotting Ammunition," J. L. Baer, Frankford Arsenal, Philadelphia, Pa.; "Latest Developments in High-Altitude Ignition of Small Rockets," Eugene Elzufon, U. S. Flare Division, Atlantic Research Corporation, Pacoima, Calif.

Also, "New Concept for Increasing Electrical Safety of Pyrotechnic Initiators," Bob Allen, McCormick Selph Associates; "Literature on Pyrotechnics," Dr. Evans; "Differential Thermal Analysis," Gary Weingarten, Picatinny Arsenal, Dover N. J.; "Introduction and Discussion of Specification: MIL-R-22449 (WEP) Requirements (Certification) for Pyrotechnics Items," Dr. J. Wintermoyer, Bureau of Naval Weapons, Washington, D. C., and R. A. Breslow, Naval Ordnance Test Station, China Lake, Calif.

The Military Pyrotechnics Section of the Bomb, Warhead and Artillery Ammunition Division also has been instrumental in collecting, reading, and making the final selection of the six papers which appeared in the November 1960 issue of WEAPONS TECHNOLOGY.

The latter publication is issued from time to time by the Association and contains unclassified papers and addresses given at meetings of the Technical Divisions and Sections. It is distributed to the members of the Divisions and to the company members of the A.O.A. as a means of furthering the Association's program.

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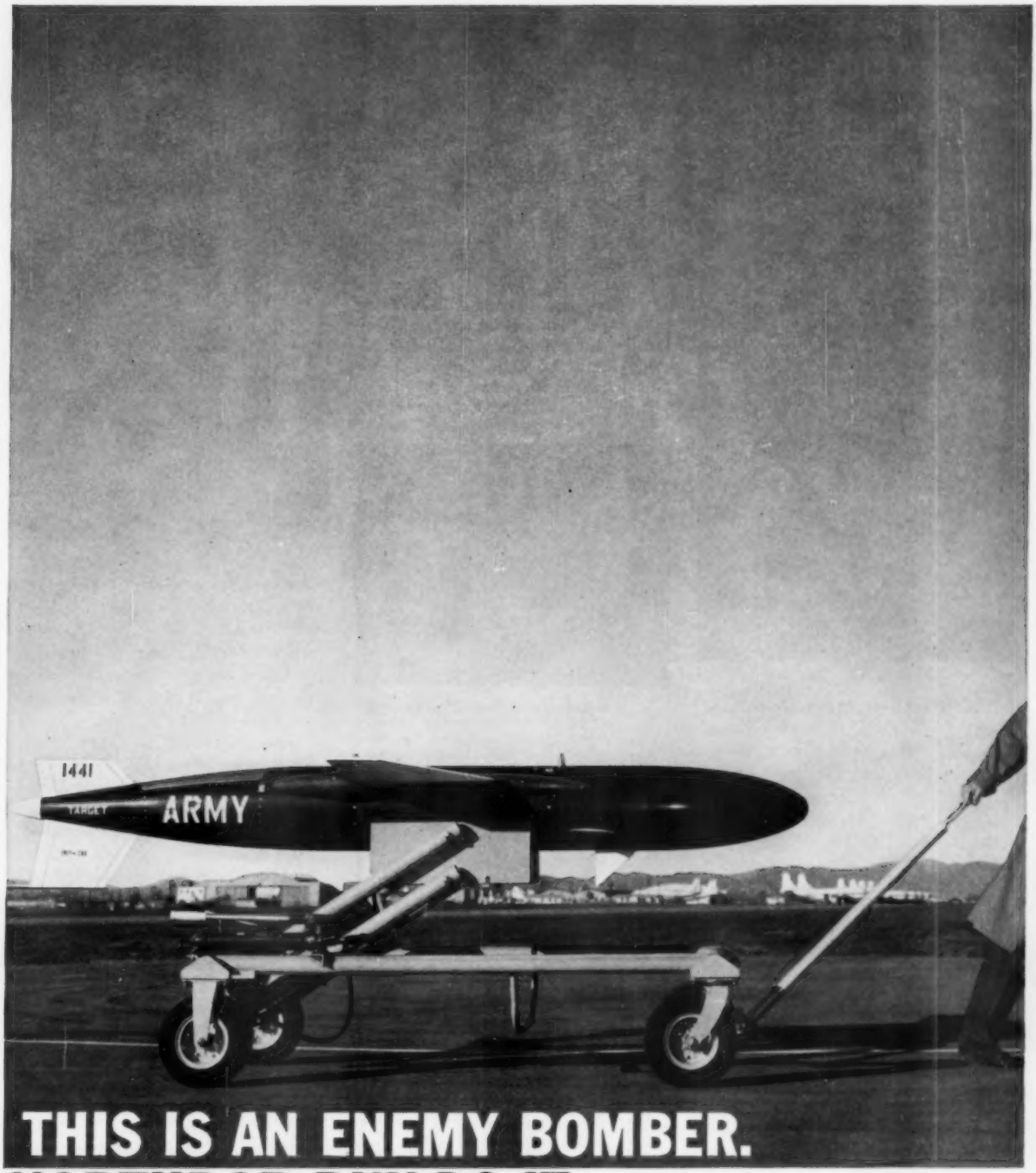

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On a radar screen, the RP-76 target missile can look as big as the largest enemy bomber. Rocket powered, it flies faster than sound, operates above 70,000 feet. Yet this little giant is less than ten feet long, weighs just over 300 pounds, and parachutes down for re-use after completing its run. It is the heart of the Army's program for training the ground-to-air missile crews who guard our cities. The complete target and tracking system is made, managed and serviced for the Army by **RADIOPLANE** A DIVISION OF **NORTHROP**

Environmental conditioning

for missile ground support systems

AiResearch electronic cooling units for U.S. Army Hawk missile mobile ground radar equipment require only half the space originally allotted. These lightweight production units, with a heat rejection capacity of 10 KW, measure 20″ x 24″ x 24″.

A complete system package, the liquid-to-air unit includes an accumulator, pump, heat exchanger, fan, switches and valves.

Contact AiResearch early in your planning and design stage for greater reliability, smaller unit size and weight. AiResearch is the leading designer and manufacturer of advanced electronic conditioning equipment and systems for missile and ground support applications.

Environmental conditioning equipment has been produced for the following electronic systems: **Detection · Communication · Control · Ground Support · Guidance**

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Los Angeles 45, California

Association Affairs (Contd.)

Container Design Section Drafts Proposal To Reduce Duplication By Contractors

A proposal to reduce duplication by military contractors of expensive specialized weapon systems containers has been made by the Container Design Section of the Packaging and Handling Division.

The proposal was drafted during a 2-day fall meeting conducted by Section Chairman T. C. Combs, Zero Manufacturing Company, Burbank, Calif., with the Librascope Division, General Precision, Inc., as host at its Glendale plant. Librascope President W. E. Bratton opened the meeting with a welcoming address.

A. F. Weissenberger, North American

W. E. Bratton, president of Librascope Division, General Precision, Inc., chats with T. C. Combs, chairman of the Association's Container Design Section.

Aviation, Inc., headed a committee that studied the problem of redundant costs in packaging weapon systems and components for shipment and storage. In many cases, he said, contractors are duplicating expensive containers because they are unaware of those already available. The committee proposed the establishment of a national index of existing containers to be distributed to military contractors.

W. G. Lawrence, Douglas Aircraft Corporation, Santa Monica, Calif., was named to head a committee to study containers that will adjust to varying environments. His group will establish criteria for designs that will control humidity, air-pressure equalization, and temperature changes.

Lawrence said containers are being designed to protect weapon systems against several environments. For example, a container carrying a submarine weapon may have to be shipped by air, loaded aboard ship in a moist climate, opened for inspection in a cold climate, and inspected again in a tropical climate.

R. J. Kurvers, Lockheed Aircraft Corporation, Van Nuys, Calif., described a unique packaging device developed for shipment of the Polaris missile which is actually a container within a container. The outer container is removed after de-

Environmental conditioning *for detection systems*

AiResearch cooling of airborne detection systems is accomplished by an extremely reliable, compact unit which is both an air-cooled cold plate and mounting structure for the detection system's transistorized power supply.

This lightweight package weighs 7.2 lb., and has a heat rejection of 500 watts. It consists of four AiResearch Minifans and an all-aluminum structure with 44 separate modules. Each module is electrically isolated and may be removed individually for quick, easy replacement.

AiResearch is the leading designer and manufacturer of such advanced electronic conditioning equipment and systems. This production unit is one example of the broad production-proven capability of AiResearch in providing extremely reliable, lightweight, compact cooling packages for aircraft, missile, space and ground support applications.

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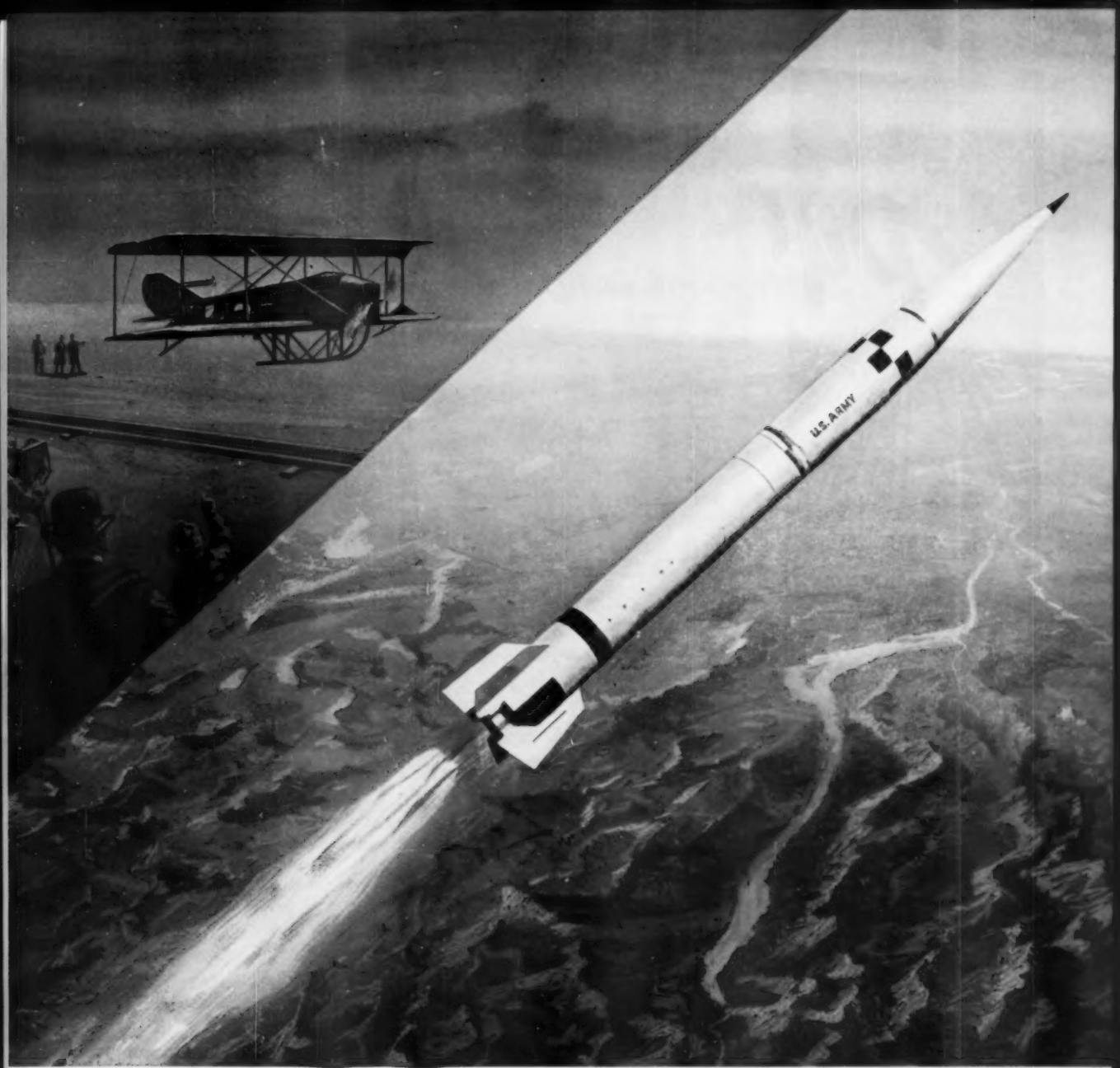

Missilry: 45 years ago, and today

There was a guided missile nearly a *half-century* ago. It was Sperry's Aerial Torpedo for the Navy—the world's first guided missile, 14 feet in length, and with a range of 50 miles at 90 mph.

Since then, a family of missiles and of missile guidance systems of ever-increasing power—and "brainpower"—has evolved at Sperry. Notable was the Navy's Sparrow I, the first operational air-to-air missile. An outstanding example today—when it becomes operational—will be the Army's Sergeant, for which Sperry is prime contractor. A medium range, surface-to-surface, inertially-guided ballistic missile, Sergeant has had a brilliant record of successful test firings. It is highly mobile and easy to operate—approaching conventional artillery in speed of emplacement and displacement.

In systems and components for missiles, too, Sperry has made major contributions. For the Army's Nike Zeus – the nation's only anti-missile missile system now in the advanced development stage for intercepting ICBMs—Sperry developed for Bell Laboratories and Western Electric extended range target tracking and discrimination radar transmitters. Other Sperry radar systems acquire, track and guide the Navy's Terrier and Talos missiles, providing precision fire control for missile cruisers, destroyers and carriers.

Sperry's role in missilry is another example of the Company's integrated capabilities—capabilities that are contributing importantly today in every major theater of our environment. General Offices: Great Neck, N. Y.

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- as a heat source
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livery to a missile-loading site. The missile is then loaded on the submarine in the inner container.

J. L. Nickel, Naval Missile Center, Pacific Missile Range, Point Mugu, Calif., outlined three principal trends for the future. He predicted greater demands for air shipment containers, a trend toward shipment of weapons in one piece rather than in several sections, and greater use of the deflatable "air-mattress" type of container.

Capt. F. L. Webre, U.S.A.F., Brookley Air Force Base, Ala., said a design cost standard and a packaging tape selection chart are two of the developmental projects sponsored by Brookley.

Maj. Gen. Marvin C. Demler Is Principal Speaker At Meeting Of Florida Post

Maj. Gen. Marvin C. Demler, Director, Aerospace Systems Management, Headquarters, U.S.A.F., was the guest speaker at the Florida Post's monthly dinner meeting on December 5th.

Col. Harold J. Crumly, Post president, presented the guests and after hearing a report from the Post secretary, Carl Kyselka, introduced the guest of honor.

General Demler discussed, "The Current Air Force Concept of Weapon Systems Management," including the "functional" type of organization utilized by the Air Force, the definition of a weapons system, and the systems-management concept life cycle that consists of three phases—"concept," "acquisition," and "operation."

He also discussed management phasing and program responsibilities; key management personnel, such as the systems program director and systems staff officer; the duties of the Weapons Board; and systems documentation.

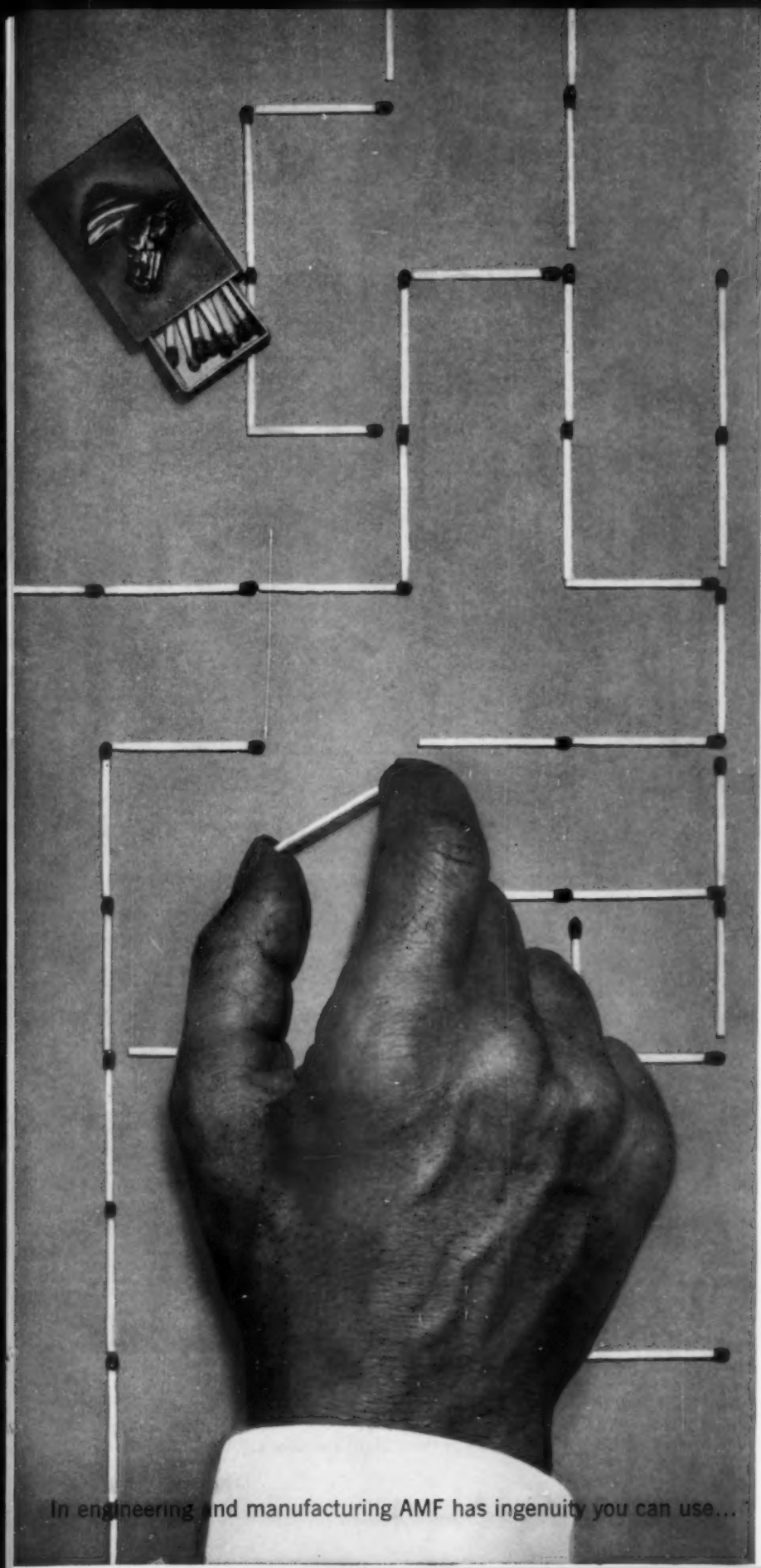
A question-and-answer period followed General Demler's excellent presentation.

Rio Grande Post Members Attend All-Day Session At Biggs Air Force Base

Forty-eight members and guests of the Rio Grande Post were treated to an all-day program at Biggs Air Force Base, El Paso, Tex., on December 14th. This program was made possible by the kind invitation of Col. S. E. Manzo, Commanding Officer of the 810th Air Division at the Base, to Col. John C. Light, U.S.A. (Ret.), president of the Rio Grande Post.

The day began with registration and coffee at the Biggs Air Force Base Officers' Open Mess. This was followed by

(*Continued on p. 673*)



He designed a new interchange for radio traffic

This AMF engineer, part of an AMF-U.S. Army team, solved the problem of traffic delays and personal danger in manual re-connection of jumpers when interchanging R.F. transmitters and antennas.

His solution is a push-button-operated, coaxial crossbar switching system, using vacuum switches for circuit selection. A typical system consists of 4 transmitter inputs, 7 antenna outputs plus a dummy load, in a 4 x 8 matrix that can be mounted in a 19" rack. It can be controlled locally or remotely over any type of communication network having a bandwidth of at least 200 cycles.

AMF's coaxial crossbar switching system provides 100% flexibility in circuit path selection and accommodates power levels as high as 500,000 watts and frequencies up to 30 megacycles. It allows 100% utilization of all transmitting equipment. Stubs are automatically eliminated.

To insure fail-safe operation, power is required for the vacuum switches *only* during change of condition. Selection rate: 1 per second. Operating transmitters are safety-interlocked to insure a load. There are no hazards from open wires or inadvertent application of power to dead-lined antennas.

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AMF's imagination and skills are organized in a *single operational unit* offering a wide range of engineering and production capabilities. Its purpose: to accept assignments at any stage from concept through development, production, and service training...and to complete them faster...in

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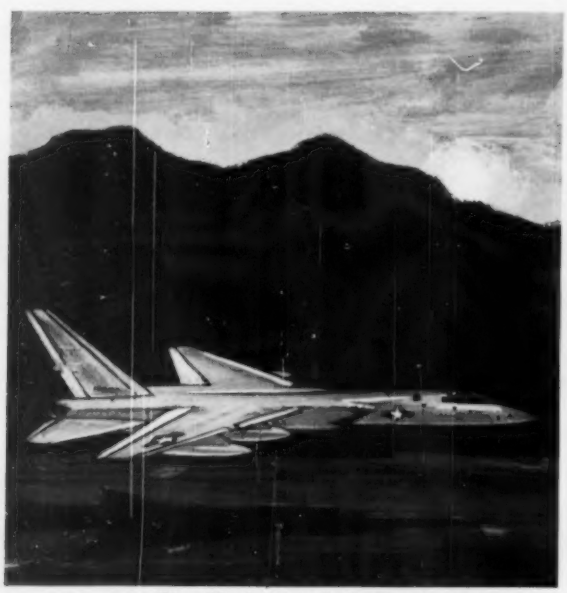
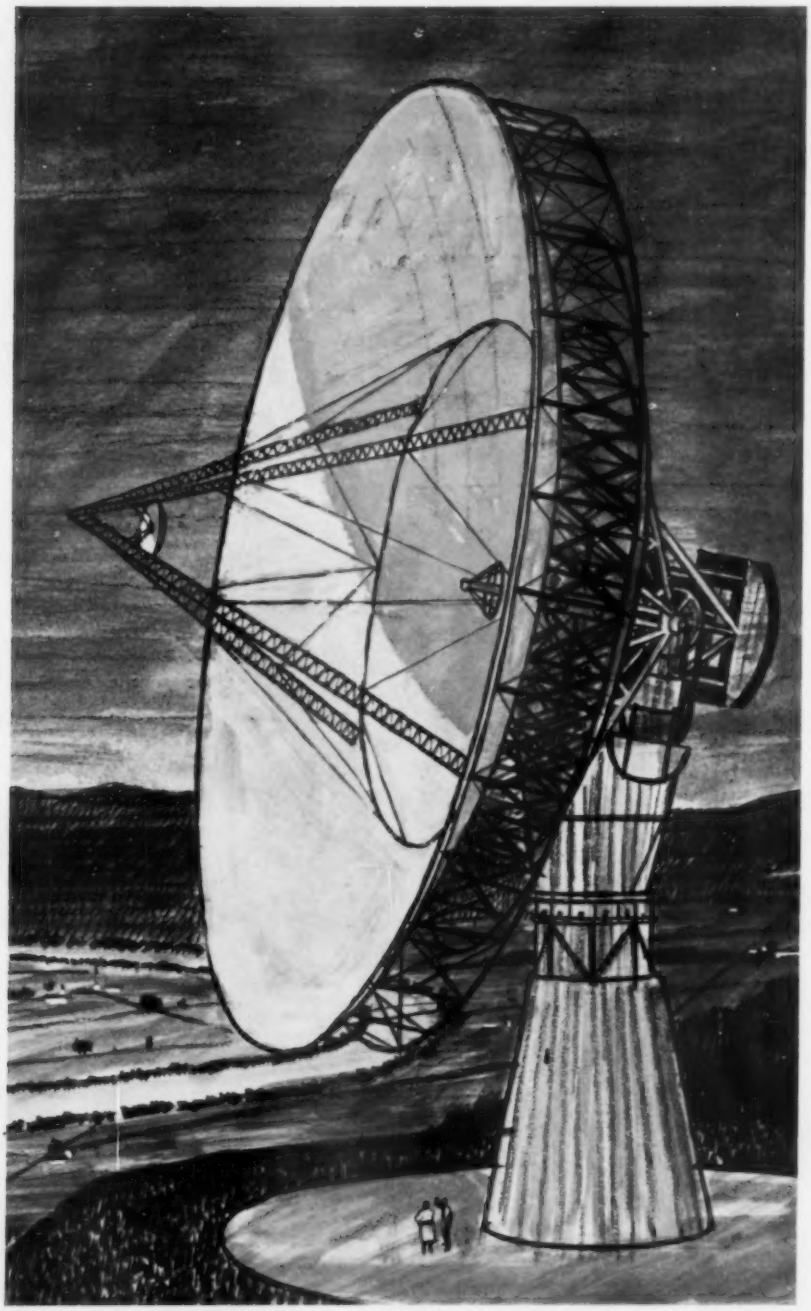
V/STOL FACILITIES. The Free World's largest wind tunnel for the study of transition from vertical to level flight is a part of the facilities at Columbus. Other V/STOL equipment includes six-degree-of-freedom flight simulator, and zero-altitude, zero-speed escape systems.



HIGH OR LOW. The Mach 2 A3J Vigilante, now being built for the Navy at Columbus, operates effectively at deck level or up in the stratosphere. The versatile A3J can perform either attack or interception missions in any weather, at any attitude or altitude, day or night.

"G" SEAT. Columbus developed unique "G" seat to study human tolerance to a high degree of vertical acceleration, and to mate human factors to the machine. Advanced low-level high-speed escape systems and pilot response in these flight regimes will be studied with it.

at NAA-Columbus



RADIO/RADAR ANTENNAS. An advanced type of antenna, constructed to such precise tolerances that it will be tuned to exact pitch, will be built by NAA-Columbus for the Air Force on "Haystack Hill" near Tyngsboro, Mass. Unique design developed at Columbus allows the rigid specifications to be met with significant reductions in dead weight, and in control power requirements.

a briefing on the Strategic Air Command's worldwide mission presented by Col. Vaughan Miller, Jr., Deputy Commander of Operations, 95th Bomb Wing. The members then toured the flight line and saw a static display of a KB-50 combination piston and jet engine refueling tanker, a KC-135 jet engine refueling tanker, and a B-52 bomber.

Following a luncheon meeting at the Biggs Air Force Base Officers' Open Mess, the Post inspected the base fire department. Highlight of the day's program was a tour of the SAC alert facility where the members saw an actual practice alert in progress.

Arrangements for this meeting were very capably handled by M. W. Stovall and Lieut. Col. George G. Kaplin.

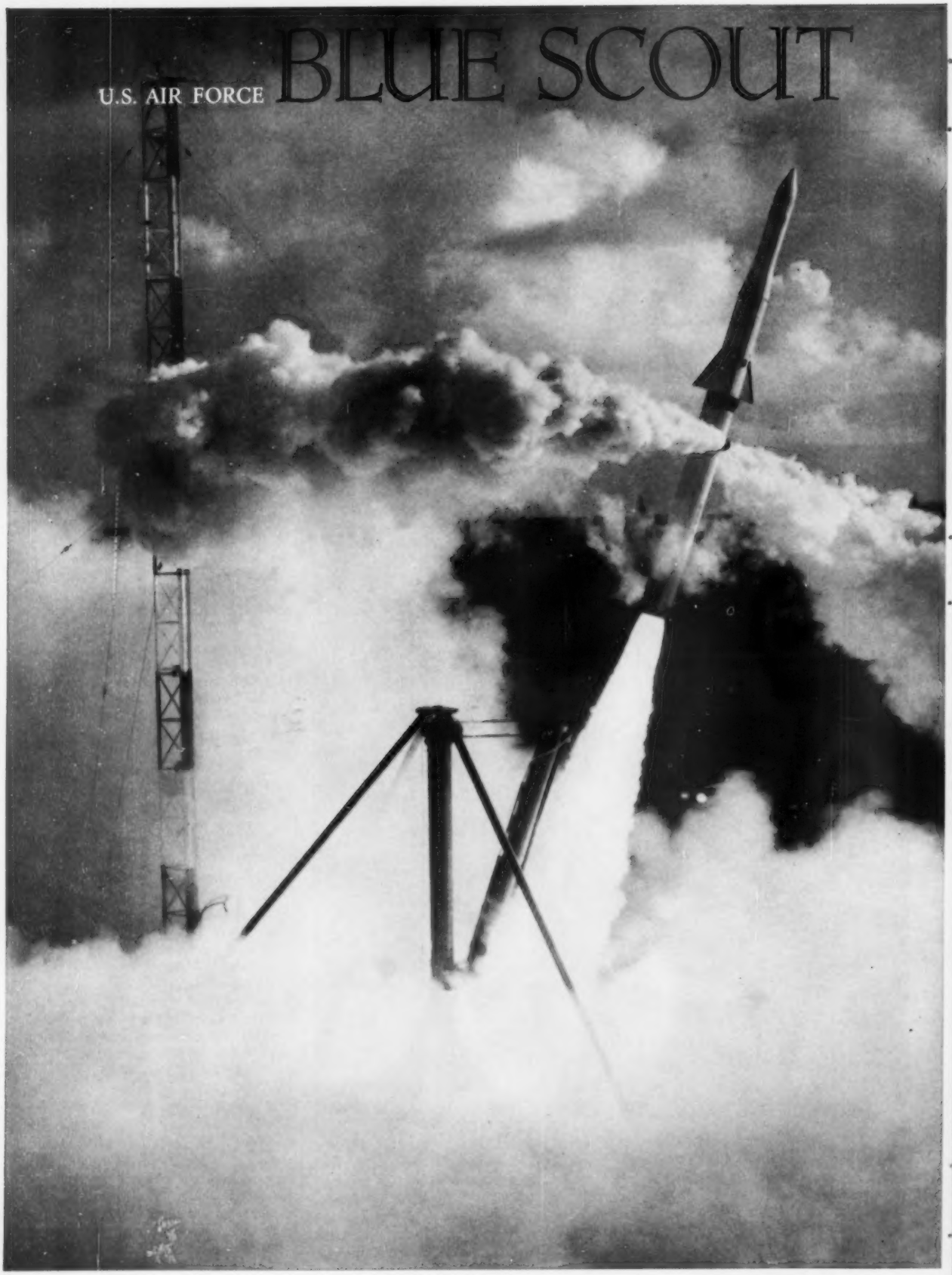
• **BRIG. GEN. ROSSWELL E. HARDY,** whose achievement in ammunition production in World War II brought him well-merited acclaim, died suddenly at Washington, D. C., January 10, 1961. Until recently he had lived in St. Louis and was a vice-president of Anheuser-Busch Company. He retired from active military service in 1951 after nearly thirty years as an Army Ordnance officer.

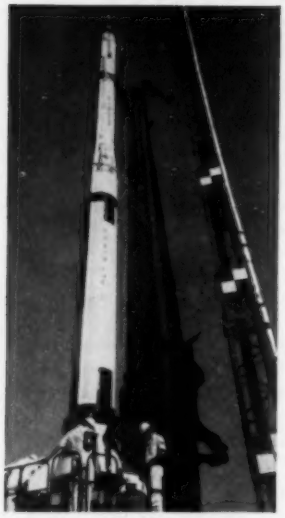
General Hardy was one of a group of ordnance specialists who brought renown to the Corps for the skill and thoroughness with which its engineering and production problems were solved over the years. He was a native of Troy, N. Y., and was graduated from Rennsselaer Polytechnic Institute in 1914.

Commissioned in the Infantry Reserve in 1917 he served throughout the First World War in that branch of the Army, transferring to the Ordnance Department in 1923. During his career he served at the Aberdeen Proving Ground, Watervliet Arsenal, Hoosier Ordnance Plant, and in the St. Louis Ordnance District. He completed courses of study at Harvard and Michigan, and was an instructor at the Command and General Staff School, Fort Leavenworth, Kans.

With the advent of World War II he supervised the construction of the Hoosier Ordnance Plant. In the following year he directed ammunition-production operations at the St. Louis Ordnance District. He was promoted to brigadier general and assigned as an Assistant Chief of Ordnance in charge of the Ammunition Division. Here his skillful direction, firm decisions, and effective administration were major factors in the tremendously successful results obtained by American industry in the quantity production of all calibers of artillery ammunition. So phenomenal was the result that produc-

(*Continued on p. 676*)


U.S. AIR FORCE
BLUE SCOUT



LEFT: USAF technicians of 6555th Test Wing under technical supervision of Aeronutronic engineers erect Blue Scout on simplified launch pad prior to successful flight. The development of Blue Scout effectively bridges gap between larger, more expensive ICBM's and smaller sounding rockets in our advanced space research and test programs. The Blue Scout is the largest solid fuel missile ever fired at Cape Canaveral.

OPPOSITE: U. S. Air Force Blue Scout Jr., lifts off launch pad as spin rockets ignite. This unguided 4-stage missile was successfully launched on the first attempt.

U.S. AIR FORCE PHOTOS

The United States Air Force Blue Scout Program provides the Nation with a new and versatile low-cost family of test vehicles to support our military weapons and space systems development programs. It can be used in a variety of deep space probes, orbit missions, boost glide trajectories, and as a rocket and satellite command and control communications system. Blue Scout has already fired a 32-pound scientific payload 16,000 miles into space ...and a 392-pound payload in a controlled trajectory 1400 miles down the Atlantic Missile Range. Aeronutronic is systems engineer, payload and test contractor on this important Air Force program.

AERONUTRONIC DIVISION *Ford Motor Company*, DEFENSE PRODUCTS GROUP
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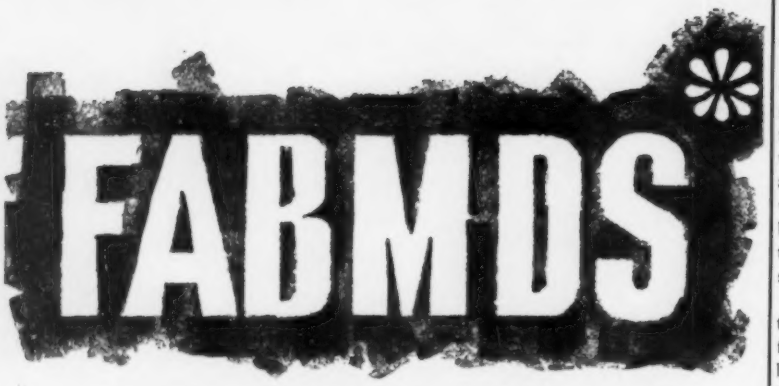
Write for information about Aeronutronic's capabilities and the career opportunities open for engineers and scientists.

The Blue Scout program, based on modifications of the NASA Scout, is under the executive direction of the U.S. Air Force Ballistic Missile Division, Air Research and Development Command. Above LEFT: Blue Scout is raised to a firing position on simplified launch pad. Because missile requires minimum ground support equipment, it is operable in a number of various field environments at minimum cost. *RIGHT:* Instrument package of Blue Scout is checked by Aeronutronic personnel and Air Force technicians. Accurate guidance system, data recovery system and final stage attitude control make Blue Scout adaptable to a wide variety of applications.



...One of many projects in Systems Engineering at General Electric's Special Programs Section

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It was for this reason that General Electric's Special Programs Section was established. Typical of its current projects is a study program for a Field Army Ballistic Missile Defense System. This system involves the integration of sensor components, communications links, data processing units, guidance, the vehicle aerodynamics, structures, stability and control, together with its launching and support equipment – all within a compatible systems structure.

To accomplish its objectives, SPS is staffed with a select group of senior engineers who act as a technical team to make systems recommendations... plan and create systems configurations and detailed specifications... establish implementation schedules... conduct continuing evaluation studies... direct and coordinate sub-contractor efforts – both within General Electric and outside the company.

Each engineer at SPS is highly competent within a broad field of technology, and has a working knowledge of several allied disciplines. He may concentrate on different aspects of a variety of problems, or follow a project, such as FABMDS, through to its completion.

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APPLIED PHYSICS	NAVIGATION AND GUIDANCE	WEAPONS SYSTEMS INTEGRATION
COMPUTER DESIGN	AIRFRAME ANALYSIS	AERODYNAMICS
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DEFENSE SYSTEMS DEPARTMENT of the Defense Electronics Division

Association Affairs (Contd.)

tion had to be tapered off long in advance of the termination of actual hostilities.

He became a respected member of the Cutback Club—an informal group of ammunition producers who succeeded in attaining difficult production schedules which were later reversed expeditiously despite all the difficulties involved. "Ross" Hardy was the rallying point for their efforts in both directions. He received the Distinguished Service Medal for his wartime service.

Following the war he became chief of the Personnel and Training Division, Office of the Chief of Army Ordnance. Later he served in Guam until his retirement when he joined the staff of Anheuser-Busch in St. Louis as vice-president and general manager.

General Hardy combined engineering skill, precise action, and a knowledge of human factors to an exceptional degree. His successes in these fields of endeavor will long be remembered gratefully by his friends and associates.

• **DR. ROBERT H. KENT,** consultant, and for many years associate technical director of the Army Ordnance Corps Ballistic Research Laboratories, died at Havre de Grace, Md., February 3, 1961. He was a charter member of the Ordnance Association and one of its most distinguished scientists. His fame as a ballistician was worldwide and well merited.

Robert Harrington Kent was born in Meriden, Conn., on July 1, 1886. He attended Harvard University, obtaining a bachelor of arts degree in 1910, master of arts in 1916, and in 1953 his alma mater conferred upon him the honorary degree of doctor of science.

After graduation he became an assistant instructor in physics and a part-time instructor in mathematics at Harvard. He was an instructor in electrical engineering at the University of Pennsylvania from 1916 to 1917.

In 1917 he entered the Army and was commissioned a first lieutenant in the Ordnance Department. He was assigned to the Office of the Chief of Ordnance and in June 1918 was ordered to Tours, France, on the staff of the Chief Ordnance Officer, American Expeditionary Forces. He was in charge of ballistic work and was responsible for the preparation of firing tables for the use of American artillery.

After the Armistice he resigned from the Army and entered upon duties as a civilian in July 1919 in the Office of the Chief of Ordnance. In 1922 he was transferred to Aberdeen Proving Ground, Md., where he served continuously since.

Dr. Kent initiated and carried on experiments to determine the aerodynamic characteristics of projectiles. For these experiments, a battery of 3.3-inch guns

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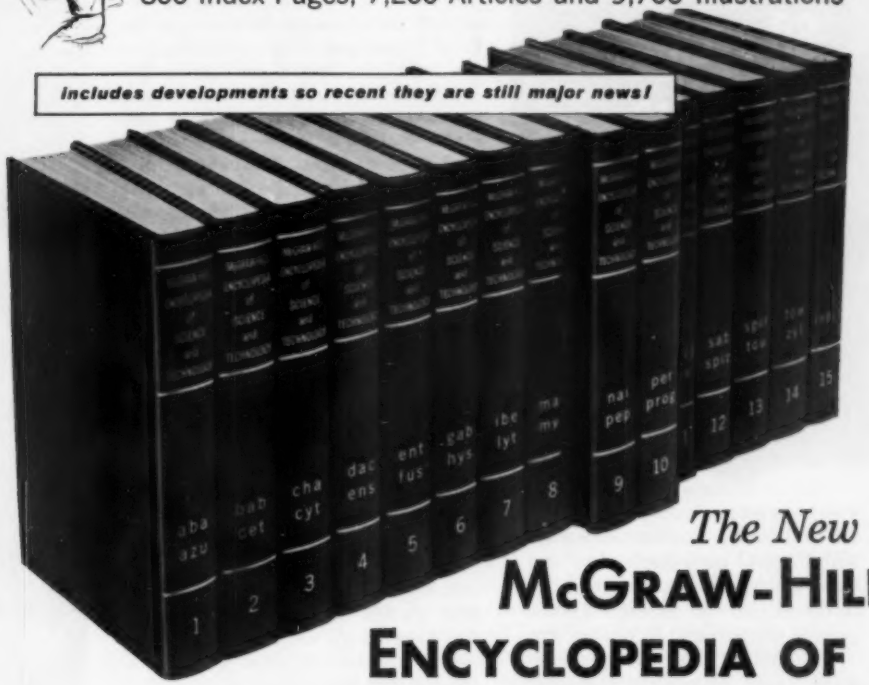

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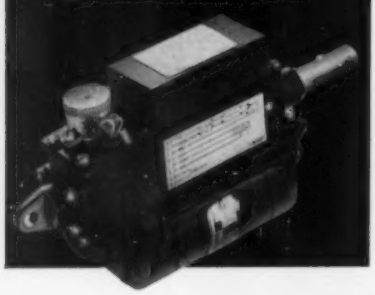

Inexpensive, lightweight 60 cycle motor driven actuators with integral magnetic brakes* are now being manufactured by AiResearch for ground radar, ground support and shipboard use.

Unequalled in 60 cycle performance, these extremely compact, lightweight actuators range from fractional hp motor size up to any desired hp in single phase, two phase and three phase design for a wide variety of applications.

The above-pictured actuator is used in a ground radar system. It is driven by a single phase 60 cycle ac fractional hp electric motor and can be furnished with a feedback potentiometer for use in servo applications. The entire unit weighs only 2½ lb. and is rated at 200 lb. operating load.

OTHER ELECTROMECHANICAL COMPONENTS AND SYSTEMS

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Your inquiries are invited.

** patented 60 cycle operated magnetic brake*

THE GARRETT CORPORATION

AiResearch Manufacturing Division

Los Angeles 45, California

Association Affairs (Contd.)

was used and resistance laws applicable to projectiles of modern shape were developed.

He worked continuously in the interior, exterior, and terminal ballistic fields at Aberdeen until Col. H. H. Zornig organized the Research Division of the Proof Department there. In 1936 the Research Division became the Ballistic Research Laboratories, and Dr. Kent became associate director, which position he held until 1948 when he became associate technical director of the laboratories.

He was chairman of the Explosives and Armament Panel, United States Air Force Scientific Advisory Board. He also was a member of the Advisory Board, Naval Ordnance Test Station, Inyokern, China Lake, Calif.

Dr. Kent was decorated with the Presidental Medal for Merit in 1946, the Potts Medal of the Franklin Institute in 1947, and the Levin H. Cambell Gold Medal of the American Ordnance Association in 1955.

• **LEROY R. BROOKS,** vice-president of the Cincinnati Post, American Ordnance Association, and president of Tool Steel, Gear & Pinion Company, died suddenly in Cincinnati on January 16, 1961. He had taken a prominent part in the Association's activities in the Cincinnati area, notably at its 42nd Annual Meeting last May.

During World War II, Mr. Brooks was in command of an ammunition ship as an officer of the United States Navy. He continued as a commander in the Naval Reserve and was president of the Naval Advisory Council of Cincinnati. His industrial, cultural, and religious interests were wide.

In 1958 he directed a campaign of the United Fine Arts Fund and was treasurer of Cincinnati's famed May Festival. He also was a member of the board of trustees of the Cincinnati Symphony Orchestra and a strong supporter of the United Appeal and the American Red Cross.

His industrial interests included membership on the board of directors of F. and F. Koenigkramer Company and the Sawbrook Steel Castings Company, and he was a past president of the American Gear Manufacturers Association. He also was a member of the board of the First National Bank of Elmwood Place. He sang regularly in the choir of the Church of the Advent in Walnut Hills.

Mr. Brooks left no effort untried to advance the ordnance cause, especially through the Cincinnati Post. He was highly esteemed by the members of the Post, particularly by the officers and directors with whom he was in constant contact. He will be missed in their deliberations and by the entire membership.

Electromechanical Components and Systems Capability

AIRESEARCH MOTORS OPERATIONAL -425° TO +600°F

Specialized aircraft motors developed by AiResearch operate at temperatures from −425° to +600° F. ambient. The range of this compact, lightweight, ½ H.P. motor is −65° to +600° F.

AiResearch diversification and experience provide full capability in the development and production of electromechanical equipment and avionic controls for aircraft, ground handling, ordnance and missile systems.

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Your inquiries are invited.

THE GARRETT CORPORATION

AiResearch Manufacturing Division

Los Angeles 45, California

SPACE ARMAMENT

Surveillance Gap Closed

The gap in the Navy silent satellite detection system stretching across the southern part of the United States will be plugged in 1961 by one of the world's largest transmitters. The 560,000-watt device to be built under U. S. Naval Research Laboratory direction southwest of Wichita Falls, Tex., near Archer City—will be five times as powerful as the largest television transmitter and will feed one of the world's longest antennas.

The new transmitter is being supplied by the Radio Corporation of America, Camden, N. J. Antenna Systems, Inc., of Hingham, Mass., has been selected to design and build the mile-long transmitting antenna. The RCA equipment, composed primarily of standard commercial transmitter equipment modified and arranged to meet the Navy's requirements, will feed power into the antenna. The latter will consist of 9 sections—each measuring approximately 576 feet long by 24 feet wide—arranged so that one can be inoperative without affecting the others.

The present Navy Space Surveillance System was built by NRL and has been in operation for 2½ years. The system has two complexes—the eastern complex extending from Georgia to the Mississippi River and the western complex stretching from California to New Mexico—with a blind spot between them. Satellites which can now make an undetected pass between the two complexes will be spotted by use of the new transmitter station, working with the existing receivers.

Institute for Space Studies

NASA is establishing a theoretical research group in New York City. Designated the Goddard Institute for Space Studies, the group will serve as an arm of the Theoretical Division of the Goddard Space Flight Center, located at Greenbelt, Md. Dr. Robert Jastrow will serve as director of the institute and will also remain in his present position as chief of the Theoretical Division at Goddard.

The institute will begin formal operations in May 1961. Its staff of approximately fifty will work in close association with the members of the faculties of universities and research institutions in the New York City area.

The program for the institute will include basic theoretical research in fields having a bearing on the NASA space-science program. Major areas of activity in the institute's program will be: the structures of the earth, the moon, and other planetary bodies in the solar system; the atmospheres of the earth and other planets; the origin and evolution of the solar system; the properties of the interplanetary plasma; sun-earth relationships; celestial mechanics; and the structure and evolutions of the stars.

Project Relay Progress

Specifications for a low-altitude active communication satellite, Project Relay, were outlined recently to representatives of forty-one industries by the National Aeronautics and Space Administration at its Goddard Space Flight Center, Greenbelt, Md.

Relay is NASA's first active communications satellite research and development project. Purposes are to demonstrate the feasibility of basic concepts and technological approaches and to evaluate the various systems to be employed in communications satellites.

First launch of an 85-pound Relay satellite with a Delta launch vehicle from Cape Canaveral will be about mid-1962. Wideband communications signals covering the range of television signals, multichannel telegraphy and data handling will be transmitted between the East Coast of the United States and Western Europe.

The payload will carry instruments to detect radiation damage and other environmental effects on critical components such as solar cells as it passes through the Van Allen radiation belts. The programmed elliptical orbit will have apogees of about 2,800 to 3,400 statute miles and perigees of about 650 to 1,600 statute miles during a period of approximately 180 minutes.

Ion Rocket Study

NASA has chosen United Aircraft Corporation's Research Laboratories, East Hartford, Conn., to conduct an ion rocket study. The firm proposes a 12-month program, using realistic thrust, power-supply, and weight data to determine the possible payloads, trajectories, and engine operating times for various specific deep-space missions. The study will include the optimum calendar times for launching the missions.

Also to be studied under this contract is a dual-thrust propulsion system. An analysis will be made of this engine combination of ion and chemical power during flight time for various missions.

The earliest class of ion rockets considered for space flights will have one-tenth of a pound of thrust and will be powered by 30-kilowatt Snap-8 nuclear reactors, after having been lifted beyond the earth's gravitational field by Atlas-Centaur or Saturn C-1 boosters. While an ion rocket's low thrust makes it a feasible source of propulsion only in the vacuum of deep space, its low fuel consumption and high specific impulse makes it possible to propel heavy payloads on long space trips.

Titan To Boost Dyna-Soar

The latest model of the Titan intercontinental ballistic missile booster will be used to boost the Dyna-Soar manned glider. Features of the advanced Titan II are a simplified propulsion system, storable propellant and oxidizer, and greater payload-boost capability. Built by the Martin Company, the Titan II will be modified for the Dyna-Soar application.

Dyna-Soar is a program to send an earth-launched, piloted test vehicle into space and, through controlled reentry, bring it back to earth. The Dyna-Soar flight vehicle, which is being developed by the Boeing Airplane Company, is a delta-winged glider designed to be capable eventually of being boosted into orbit and then to descend into the atmosphere and land on a normal airstrip.

Building-Block Propellant

The NASA recently announced the successful firing of a solid-propellant rocket motor made by a new "building-block" method. The motor was manufactured in three separate pieces, each weighing about half a ton. These "building blocks" were transported separately to the test site, assembled into the complete motor, and fired.

The successful demonstration of the building-block concept is an important milestone in NASA's program to establish the feasibility of very large solid rocket motors. Such rockets would have sufficient thrust to launch space vehicles in the multimillion-pound range.

Since a motor for such a purpose may be as large as ten feet in diameter and eighty feet long, it would be difficult to transport as one unit. The building-block concept removes this difficulty and in addition permits much of the necessary proof-testing of propellant, nozzles, and internal insulation to be done with relatively small segments.

The most proven large ballistic missiles, the Atlas (left) and Redstone (right), will launch America's Astronauts. Main-stage engines of both are by Rocketdyne.

AMERICA'S ASTRONAUTS WILL BE LAUNCHED INTO SPACE BY ROCKETDYNE ENGINES

America's man-in-space programs demand the ultimate in reliability. There is no room for error—that is why America's most experienced rocket engines have been chosen for the job.

And this means engines built by Rocketdyne.

A Redstone engine, whose performance over a decade of development includes 62 consecutive successful flights, will loft the first manned space craft high over the Atlantic in an exploratory ballistic arc.

Then an Atlas system of five engines, proven in more than 60 development and operational flights, will send a man soaring upward more than 100 miles to circle earth for four hours during man's first orbital flight in space.

To that dramatic moment, Redstone and Atlas will carry the heritage of more than 18,500 large engine tests at Rocketdyne's Propulsion Field Laboratory.

At every level of operation—from engineering to manufacturing to cost control—Rocketdyne has pioneered new concepts. Advanced management programs, combined with vast experience and the foremost high-thrust test facilities in the nation, give Rocketdyne the capability today to meet the challenges of tomorrow.

Rocketdyne engines have launched more than 250 missiles, satellites, and space probes.

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MISSILE SUPPORT EQUIPMENT

Robert S. Sartoris

• *Since Missile Support Equipment is accounting for an increasingly large share of total system expenditures,* ORDNANCE *magazine is instituting this department as an entity separate from columns covering missiles and electronics. To introduce the new area, writer Robert Sartoris has devoted this column to discussing the major problems and outlook for MSE suppliers and users.*

Future articles on the subject will include major news of program developments and notable accomplishments. Individuals or companies are invited to keep ORDNANCE *readers informed of their MSE activities by sending press releases, technical papers, addresses, etc., to the author at 291 Edgerton Road, Akron 3, Ohio.*

While it is still early to predict total defense expenditures for fiscal year 1962, there is little question that missile support equipment will continue to grow as a factor in missile and defense budgets, possibly accounting for nearly a third of the total missile system dollar by the end of fiscal 1962.

In the research, development, test and evaluation phase alone, the 1961 missile support tab already comes close to the half-billion-dollar mark, ranging from ten per cent of development costs for an air-to-air missile to sixty per cent for hard-based, liquid-propellant birds.

This is a remarkable growth, for it hasn't been many months since MSE was considered as an afterthought to be worked out only after the more glamourous missile features had been completed. But, while MSE is coming into its own in grand style, there are still a great many problems and areas in the state of the art that need substantial attention.

One of the more perplexing missile-system questions that will have a profound effect on MSE is that of hardened launch sites versus mobile units.

Advocates of mobile systems say that, despite construction of mighty components to withstand a nuclear near miss, any near-by blast may damage the more delicate parts.

For example, although heavy doors covering a launch pit might easily withstand a blast in close proximity, shock waves from the blast could knock more fragile hinges or actuating gear out of kilter, binding up the doors and rendering the protected missile just as impotent as if it had been destroyed by the blast itself.

"Hard" men respond with the rather compelling logic that, while there might be weak points in hard-site operation, at least they have been able to get the birds off the ground while, so far, the mobileers have only been able to talk a good game.

Polaris, major contradiction to that argument to date, points up still another drawback, "hard" men say. With current complexity of the checkout and launch procedure, a large number of highly trained experts are required for each launch site. For logistic reasons (as well as the short supply of such experts) this factor reduces the term "mobile" to a matter of relativity, they say.

Target of the "hard" men is the Air Force Minuteman, admittedly a Johnny-come-lately in terms of mobility. Like Atlas and Titan, the Minuteman was designed for a hard site. But, shorter, lighter, and cheaper than its big brother ICBM's and using solid instead of liquid fuels, Minuteman presents the best tool available for testing the mobility concept.

Nevertheless, it is a delicate instrument and was not designed to withstand the shocks involved in overland transportation. As such, a good part of making it mobile currently lies in providing protection against shock, such as cushioned frames and couplings and inflatable rubber air mattresses.

There is no question that more attention will have to be given to increased ruggedness during initial design of missiles intended for mobile use. Second-generation mobile ICBM's probably will be carried on truck-towed launchers such as are used in the TM76A Mace missile, now operational with TAC in Europe. Before that can happen, however, considerable study will be required in weight-reduction, increased power of propellants, and decreased complexity in checkout procedures and equipment.

Improvements in the latter field are not on the horizon. In fact, the opposite seems to be the trend as missile-equipment makers and users require more and more checkout devices.

According to the watchdogs of the Nation's treasury and the military men who are becoming more conscious of the shortage of highly trained field personnel equipped to handle such complex equipment, the U. S. is overbreeding. Instead of developing a breed of dependable, rugged, workhorse missiles, they say we are building a strain of delicate and unstable race horses, so high-strung that we might not be able to get them into the starting gate at post time.

At the current rate, critics claim, support equipment for future birds will require "checkers to check checkout checker checkout equipment," and each switch on the console will have to be unlocked with a Phi Beta Kappa key.

Compared with the U. S. approach is the avenue taken by Russia. Because the Soviets are faced with tremendous transportation problems in carrying missiles over 6,000 miles of poor roads and mediocre rail equipment from their relatively few manufacturing plants, they have built their missiles rugged, mobile, and simple enough to be operated by the relatively untrained army personnel available to them.

Admittedly, this simplicity has some adverse effect on accuracy, but it also increases considerably the number of missiles that can be bought with a given number of rubles—or dollars.

U. S. missile makers and users cite good reasons for increased complexity. First, they say, prelaunch error correction undoubtedly reduces the number of aborts and failures, saving time, money, and the missiles themselves. And the point of diminishing returns in such savings versus the cost of added complexity is now receiving added scrutiny in the military's current cost-cutting campaigns.

Secondly, with the increased amount of data recorded by the more complex equipment, so-called "failures" have been made to bear fruit in terms of added education. It is justifiably claimed that information obtained in this way has helped the U. S. make good strides in catching up with our space-race competition.

Thirdly, the increase in proportion of

Mr. Sartoris is missile, space, and technical representative on the public-relations staff of the Goodyear Aircraft Corporation, Akron, Ohio.

Missile Support Equipment

MSE money out of total system funds is not caused entirely by increased complexity, but also reflects a difference in basic philosophy in some instances. As in the case of the Nike Zeus missile killer, more of the birds' brains are being kept on the ground where they can be used over again instead of going to their death with the missiles.

While this may cost more initially, it reduces the cost of operational vehicles at such time as they are produced in quantity.

Finally, users and suppliers admit privately that increased complexity in checkout gear is also partly a matter of self-preservation. Faced with increased publicity and the Nation's near-hysteria as regards our national "prestige," they are under considerable pressure to avoid any failures—the users under pressure of the always-present specter of Capitol budget-juggling and suppliers under that of intense industry competition.

Regardless of contentions on both sides, however, the argument will continue to plague both makers and users with increasing intensity. As a result, while FY '62 promises to be a good year for MSE suppliers, it will also be a year for tightening operations and justifying activities.

As mobility becomes an increasing factor in the big birds, the industry will be faced with yet another problem . . . that of logistics or getting new missiles to the launching complex. While special trailers can and have been devised for carrying them overland, as in the case of Atlas, the routes have been extremely circuitous to avoid low bridges and narrow spots.

At sea, as in the case of Polaris, the problem is even more severe. Transfer of a missile from supply ship to launching vehicle in anything short of perfect weather is out of the question with current techniques, but long trips "deadheading" for a new load put the sub in definite danger and waste a great deal of the time away from operation.

The problem will become more acute with development of larger space vehicles. A special barge will carry Saturn to its launching pad, but what about Nova and others of that order? Will they all have to be shipped in units and assembled at site or will it be necessary to build some sort of super air carriers such as the proposed giant gliders or blimps to transport the big missiles.

Thus, while growth of the MSE industry is certain, that growth is also making life more complicated. The larger the part it plays in the missile business and the more defense money it receives, the more public scrutiny and criticism it will be exposed to and the more challenging will be its problems.

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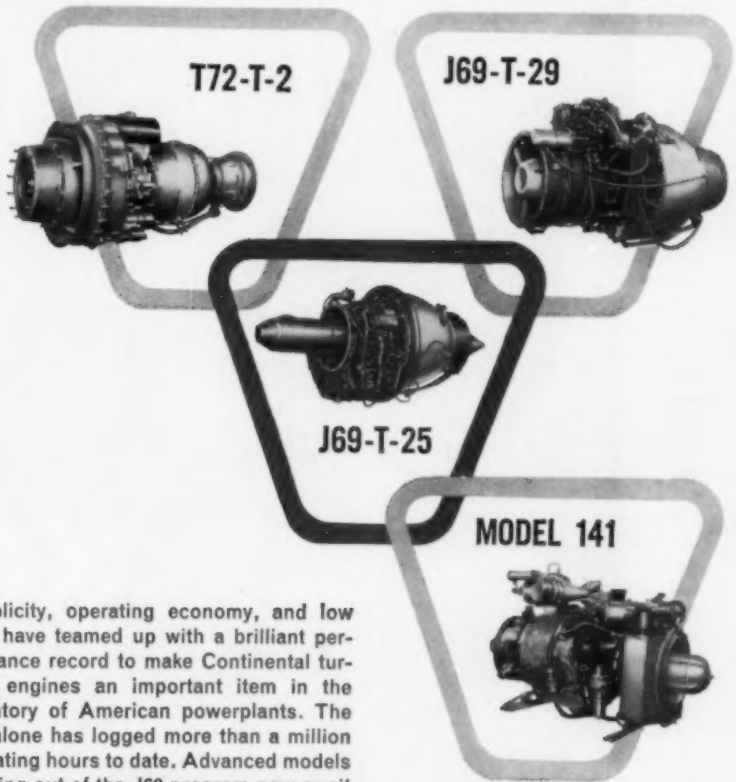

Simplicity, operating economy, and low cost have teamed up with a brilliant performance record to make Continental turbine engines an important item in the inventory of American powerplants. The J69 alone has logged more than a million operating hours to date. Advanced models growing out of the J69 program now await industry application. They include aircraft turbojets of 1,400 and 2,400 lbs. thrust, "aft-fan" turbofan engines of 2,600 and 4,000 lbs. thrust, a target-missile turbojet of 2,550 lbs. thrust, altitude thrust augmentation devices for existing turbojets, and the J69-T-35 air pump for boundary layer control. Rounding out Continental's capability in the field of aircraft propulsion is a completely new series of turboshaft and turboprop engines, including the 500-hp, 6,000-rpm 217-5A (U. S. Navy designation T72-T-2) turboshaft, which promises to find use in a wide variety of applications.

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NEW DEVELOPMENTS

Antitank Rocket Grenade

The Army-Industry Team has developed a new antitank rocket grenade that can be fired from its own disposable packing container. The XM72 rocket grenade can be carried and fired by one man. The weapon is highly effective against tanks, armored vehicles, concrete bunkers, earth-filled log emplacements, and sandbag fortifications.

Small, light, and simple to operate, the new grenade is readily adaptable to mass production. (See photos on page 644.)

The 4½-pound XM72 is carried over the shoulder in a throwaway case that serves as the launcher. Each grenade is fitted with a canvas sling to permit shoulder carrying. If desired, four rounds can be carried in a canvas pack slung over the shoulder like a quiver of arrows.

The carrying case is twenty-five inches long and three inches in diameter. A telescopic aluminum inner section is extended prior to firing. The outer section is made of a fiber glass plastic composition. The weapon can be fired from standing, kneeling, or prone position.

A solid-fuel motor furnishes propulsion and burns out before the rocket leaves the tube. When the rocket emerges, several narrow magnesium fins, folded against the motor case when packed in the tube, spring into position and stabilize the rocket in flight.

Aiming is accomplished by a rear peep sight and a graduated sight imprinted on a clear plastic rectangle at the mouth of the launcher tube. The firing mechanism is mounted on top of the launcher tube.

The warhead uses a powerful new Army Ordnance-developed explosive known as Octol. Teamed with the 90-mm. recoilless rifle, the new rocket grenade will satisfy the infantry soldier's need for protection against enemy tank attacks.

The Hesse-Eastern Division, Flightex Fabrics, Inc., Everett, Mass., is the prime systems contractor.

New Nuclear Generator

A new lightweight nuclear generator which converts heat directly into electrical power is undergoing performance testing at the Air Research and Development Command's Air Force Special Weapons Center in Albuquerque, N. Mex.

The completely portable nuclear auxiliary power device, which weighs considerably less than 40 pounds, was designed and constructed by the Westinghouse New Products Laboratory in Pittsburgh, Pa., under Air Force contract to provide a reliable and long-life power source for facilities such as small unmanned surface radio beacons and weather stations.

The generator, designated NAP-100, produces approximately 150 watts of electrical power and was designed for one year of continuous unattended operation. It is designed to use radioactive isotopes, such as curium 242 as its heat source.

The generator's 144 small semiconductive elements are heated by the heat source to a temperature of about 1,000 degrees Fahrenheit. Finned heat exchangers, which cover the generator like the quills on a procupine, keep the ends of the elements farthest from the heat source at a temperature of 300 degrees. This temperature difference produces a flow of electrical current in the elements.

Only ten inches high, with a diameter of sixteen inches, the generator has the highest efficiency of any direct-conversion electrical power device of comparable size.

It also produces more power per pound of generator weight than any similar device.

Articulated Vehicle

The Aeronautics Division of Chance Vought Aircraft, Inc., has built and is field testing a multipurpose 6-wheeled amphibious military vehicle, the "Gama Goat," designed to give ground forces high mobility in all types of terrain.

The amphibious Gama Goat.

The lightweight, articulated 6-by-6 vehicle uses a novel design concept. Uniform loading on all six wheels gives it "sure-footed" capacity on hills and rough terrain, through ditches, snow, sand, bogs, and swamps. It also can ford rivers.

The rear body of the vehicle can be detached from the front body, thus enabling the loaded rear to be delivered to its destination and a new one substituted. The rear is adaptable as a troop carrier, missile transport, cargo carrier, ammunition transport, flame thrower, ambulance, and a number of other military uses.

Power for the vehicle is provided by an 80-horsepower air-cooled automotive engine. It has four forward transmission speeds, will do up to 50 miles an hour, and has a range of 1,000 miles. Weight is 3,100 pounds empty which makes it suited for air transport or for air drop by parachute.

Air Duct Signals

Navy scientists have successfully transmitted radio signals over unusually long distances by guiding the waves through "ducts" in the air formed between dry and wet air layers. The experiment is called Project Trade Winds III.

Scientists from the U. S. Naval Research Laboratory at Washington, D. C., and the U. S. Navy Electronics Laboratory, San Diego, Calif., transmitted signals from California which were received in Hawaii 2,600 statute miles away. The same signals, if not directed by the air ducts, would have traveled only about 575 miles.

Basic equipment used in Project Trade Winds III consisted of dual-frequency receiver equipment aboard one of the 4-engined NRL aircraft, very high frequency (VHF) transmitter equipment in a second NRL aircraft, NEL transmitters in San Diego and Oahu Island, and the ultrahigh-frequency (UHF) moonbounce transmitter at Oahu. The third WV-2 aircraft, a Navy Pacific Barrier picket plane, gathered additional weather data to assist the experiment. The recordings of this array of ground-to-air and air-to-air signals and the associated meteorological measurements added greatly to the knowledge of this type of radio communication.

Lightweight Engine

A California engineering company has disclosed a 4-cylinder 175-pound engine which develops 175 horsepower. The secret of this small powerhouse is an engine block assembly made of thin stainless steel sheet which contributes to the engine's high power, lightness, and durability and also eliminates corrosion problems in the water-cooled unit. Another advantage is that the engine dissipates its oper-

(Continued on p. 688)

Hear this . . . Somewhere under the seven seas, part of the Navy's nuclear deterrent force is on station. Aboard the Polaris submarine George Washington command communications equipment stands ready for operation. This equipment was developed by Avco. Highly skilled scientists and engineers of Avco's new Undersea Projects Office are working on antisubmarine warfare problems and research on related underwater phenomena.

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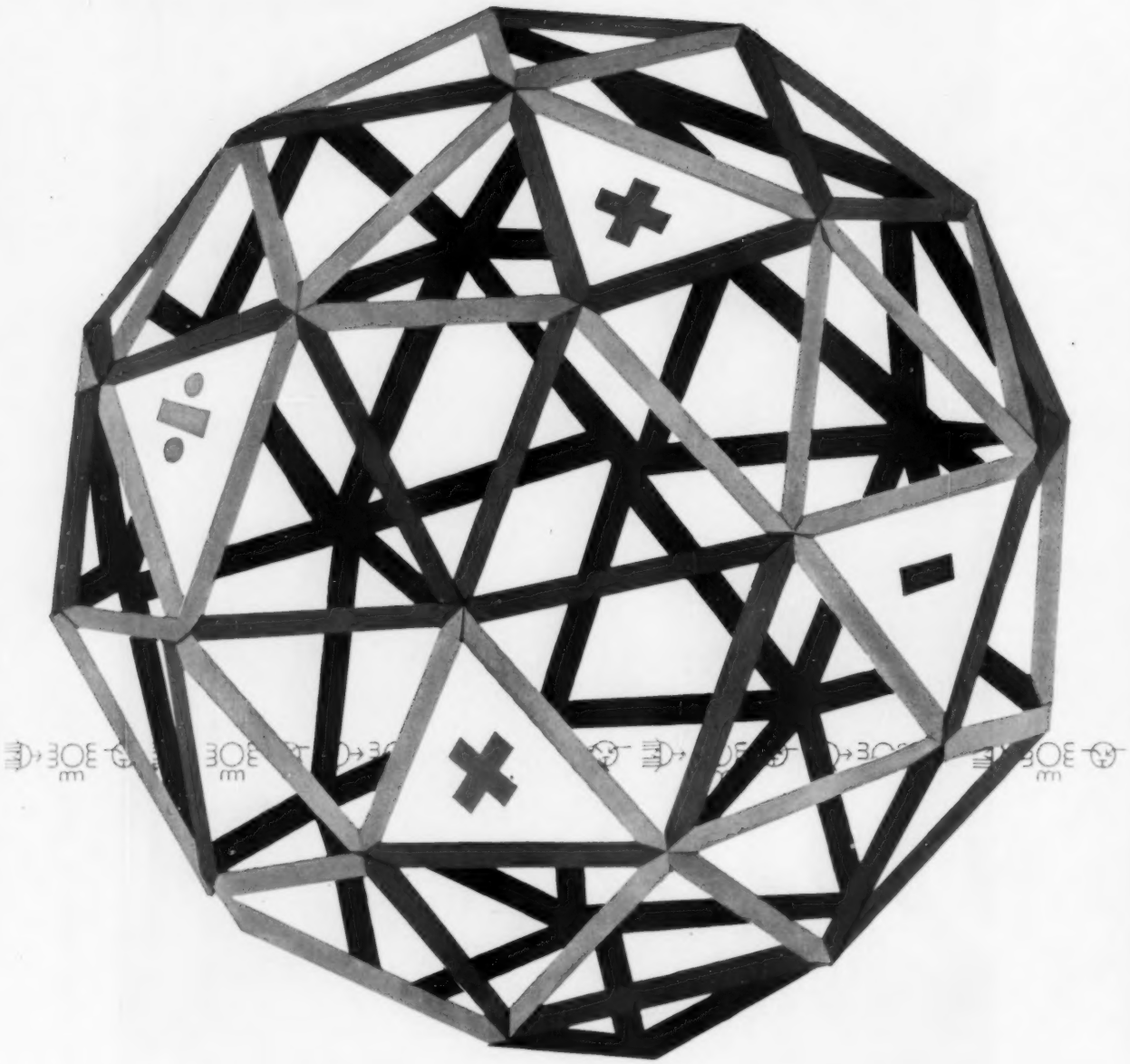

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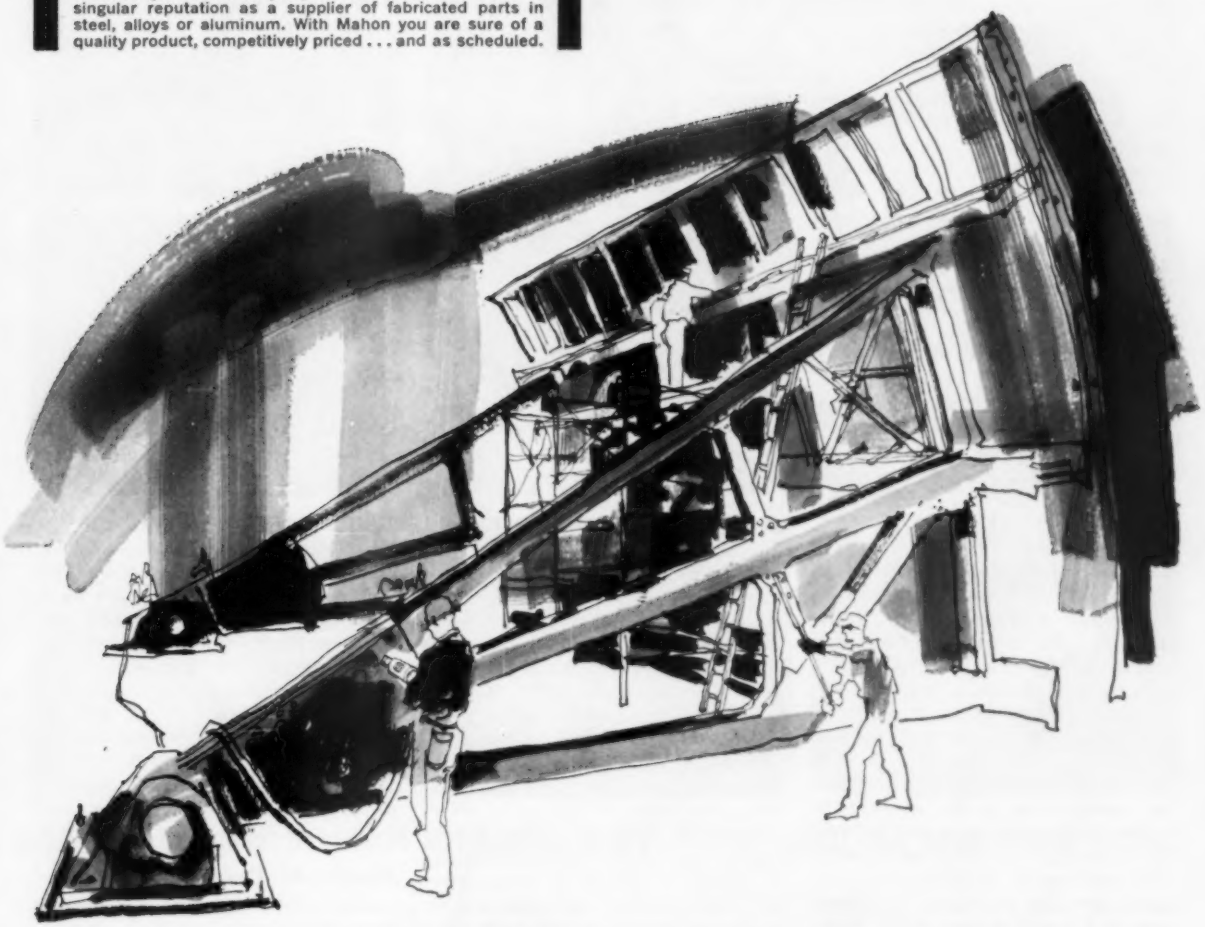

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ating heat quickly and uniformly. This uniformity eliminates the "hot spots" that cause pinging in conventional engines.

New Shell Process

The U. S. Army Ordnance Special Weapons-Ammunition Command, with headquarters at Picatinny Arsenal, Dover, N. J., has been instrumental in the development of a new process which sharply reduces the cost of producing an 8-inch artillery shell.

The new process, developed jointly by the Army Ordnance Corps and the U. S. Hoffman Machinery Corporation, which operates the Scranton, Pa., Ordnance Plant under Government contract, employs unfinished steel costing $19 a ton less than the premium steel formerly used. Potential savings will amount to one million dollars a year in peacetime.

New precision manufacturing techniques have reduced metal scrap and cut the amount of steel needed to forge shell. Reduction in the steel tonnage requirements would be of great importance to commercial steel users in event of a war.

Minuteman Car Completed

The accelerated development program for the Air Force Minuteman intercontinental ballistic missile system moved a step nearer with the completion of the first railroad car that will serve as a launching pad for the nuclear-tipped weapon.

Boeing Airplane Company, which will outfit the interior of the car with launch gear, is the weapon-system integrator for the 3-stage, solid-fueled missile. It selected the team of American Machine & Foundry Company and ACF Industries, Inc., jointly to design, develop, and produce cars from which the missile could be launched as well as command cars that will be used for control and operations. ACF also is developing the power-car rolling stock for the missile train.

The 12-wheel missile car uses hydraulic shock absorption for maximum protection from end impact; a compressed-air reservoir that always returns the cushioning gear to a neutral position relative to the underframe following an impact; air springs and leveling valves to keep coupler height constant whether or not the more-than-30-ton missile is on board; standard helical springs for additional protection; and special devices that decrease the effects of irregularities in the rails.

At the time of a shoot the car would come to a complete stop and a truck-lockout system would be engaged to lock the trucks (wheels, axles, and cushioning gear) temporarily to the underframe of the car. Then twelve jack pads would descend and raise the car into its final launch position. Connected to those jacks nearest the actual launch pad at one end of the car is a 10-foot-square steel flame deflector that lowers over the ties and rails and protects them from the missile blast.

The launch area door then slides toward the end of the car, leaving an opening directly over the launch pad. The main roof doors, each 45 feet long and half the width of the car, then open and the missile is raised to its launch position on the pad.

A "Universal" Tractor

A crawler tractor, that is a combination of dozer, scraper, dump truck, grader, cargo carrier, and high-speed prime mover is currently under test by International Harvester Company.

In addition to its varied capabilities as an earthmover and cargo carrier, the unorthodox vehicle is also designed to carry personnel and weapons, like mortars, and to operate with such allied equipment as crane booms, conveyor belts, winches, and earth augers.

New universal engineer tractor.

While many of its functions are essentially land operations, the experimental tractor represents a radical departure from the earthbound machines it would replace. Meeting modern warfare's demands for ultraflexibility, the tractor has been designed to travel by air and to be dropped (by six 100-foot parachutes) at the scene of action.

The UET also is amphibious and its crawler tracks will propel it across rivers and lakes at a speed of four miles a hour. It is also built for deep fording and for working and towing in water to a depth of more than six feet.

The problem of working weight on the ground was solved by designing the UET to load itself with earth (or other locally available ballast), making it possible, on the ground, to double the airborne weight and providing a maximum drawbar pull of 17½ tons—equivalent to that of a conventional tractor of twice the UET's empty weight.

Key to the feasibility of the UET is its hydropneumatic suspension system which literally permits the operator to turn his springs on and off at will with a control handle on the instrument panel. Sprung, the UET crawler can move along smoothly at a top speed of 30 m.p.h. Unsprung, it can move earth, work with a crane boom or auger, or provide a firm emplacement for a mortar in action.

Nike Zeus Radar Tests

Preliminary testing of the Nike Zeus system's massive target-track radar has started on Ascension Island. The radar equipment, with great range and unprecedented accuracy, has been installed and energized. It is now being checked out so that it can track intercontinental ballistic missiles fired down the Atlantic Missile Range from Cape Canaveral, Fla.

A computer also has been installed which will record phenomena associated with intercontinental ballistic missiles tracked by radar. These records, stored on magnetic tape, will be used in advanced testing of the Nike Zeus missile. The recorded trajectories will be fed into computers at White Sands Missile Range, N. Mex., and at Point Mugu, Calif., where test firings of the Nike Zeus will be conducted. The recordings will be used in a "synthetic intercept" program.

Instead of having an ICBM as an actual target, the tape will be used to simulate it. The target intercept computer, which tells the defending Zeus missile where the target is in space and where the antimissile missile must go to intercept the target, will utilize the data recorded on the Ascension Island tapes.

Julie-Jezebel

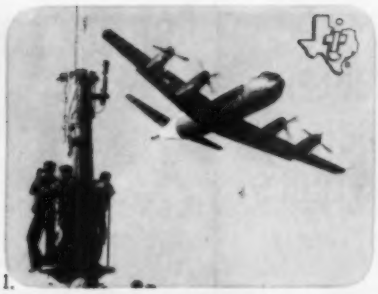
Lockheed Aircraft Company, Burbank, Calif., is installing Julie-Jezebel detection equipment on sixty-nine Neptune antisubmarine aircraft for the Navy. The new equipment permits underwater detection at greater ranges. The Julie system uses floating buoys that employ an explosive sound source for echo ranging, while the Jezebel buoys locate the submarine by triangulating on the noises it produces. The two systems are linked together in the airplane's electronic equipment. Both are being put on new planes in production.

Marine Air Defense System

The Marine Corps has taken delivery of the world's first helicopter-transportable electronic air-defense control system. Developed by the Hughes Aircraft Company, the "Airtrac" system will coordinate split-second firing of Hawk and Terrier guided-missile batteries at hostile supersonic aircraft.

The equipment is installed and transported in helihuts—portable plastic and aluminum shelters which are carried underneath a helicopter. Capable of being placed in operation within minutes anywhere a helicopter can land, the "Airtrac" is designed to furnish tactical support to Marine ground troops by coordinating the firing of antiaircraft missile batteries.

TI IN MILITARY ELECTRONIC SYSTEMS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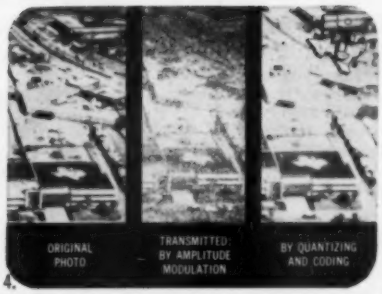

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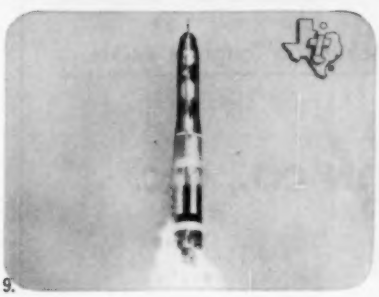
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Equipment, designed, developed and manufactured by TI now operational in the Armed Forces:

1. U. S. Navy P3V-1 antisubmarine aircraft produced by Lockheed—equipped with AN/APS-80 surface search radar, AN/APA-125A indicator, and additional gear (nomenclature classified).
2. TARmac ASR-4 Airport Surveillance Radar for the Federal Aviation Agency.
3. Infrared optics for the U.S.A.F. FALCON Air-to-Air Missile, built by Hughes.
4. Quantized photograph, transmitted by PCM code, results in faithful transmission and improved reproduction over great distances.
5. AN/APS-38A surface search radar, AN/ASQ-8 magnetic anomaly detector for the U. S. Navy S2F-1 ASW aircraft, built by Grumman.
6. CENTAUR (A United States Space Vehicle) will report back through TI-built FM/FM telemetry.
7. AN/AQS-4 and AN/AQS-5 dipping sonar for the U. S. Navy HSS-1N ASW helicopter, built by Sikorsky.
8. AN/APS-80 surface search radar, AN/APA-125A radar indicator, AN/ASQ-8 magnetic anomaly detector and TD-239A intervalometer for the U.S. Navy P5M-2 ASW seaplane, produced by Martin.
9. Programmers for the U.S.A.F. TITAN Intercontinental Ballistic Missile, built by Martin.
10. TI electronic flight control in Douglas Aircraft's Delta launch vehicle helped orbit the NASA weather satellite TIROS II.
11. Surveillance sensors for the U. S. Army Signal Corps AN/USD-5 Combat Reconnaissance Drone, produced by Fairchild.

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INCORPORATED

APPARATUS DIVISION

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ARMA

PRODUCING ALL-INERTIAL GUIDANCE FOR ATLAS

Many successful full-range test flights have proved the reliability and accuracy of the Arma inertial guidance system now in full production. Other advantages—salvo firing, immunity to jamming, low cost, a minimum of ground support equipment—are inherent in inertial guidance. Currently at Arma, company-funded research programs are studying smaller, super-sensitive devices for navigation and satellite instrumentation.

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AMERICAN BOSCH ARMA CORPORATION

UNDERWATER ORDNANCE

Seabrook Hull

Amphibious Assault Support.—The Navy is taking more than a casual second look at the possibilities raised by giving submarines the capability of providing firepower support to amphibious troop landings. No, they're not thinking of putting deck guns back on the high-speed nuclear submarines now in service.

But Navy planners are intrigued at a suggestion to equip submarines with yet another class of missile—essentially the eye-guided, wire-controlled type now being adopted for antitank operations by the Army.

Idea is that a submarine, lurking offshore at periscope depth, could pop these birds up pneumatically and then guide them visually to their targets. The present study could lead to a whole new family of PSW (prosubmarine warfare) weapons.

Supercavitating Propeller.—Naval Ordnance Test Station, China Lake, Calif., has mounted a supercavitating propeller on its Retorc-1 research torpedo as part of its program of evaluation and development of the supercavitating principle.

Cavitation—the hydrodynamic equivalent of aerodynamic's boundary-layer separation—has longed plagued efforts to achieve higher underwater speeds without major loss of efficiency or increase in noise. Vehicle hulls, as well as propellers, are subject to the phenomenon. It works roughly as follows:

Take any angle of departure of the normal hull line from the direction of hydrodynamic flow (or any angle of attack on a propeller blade). There is at some speed a point where boundary-layer separation will take place. This is cavitation. However, as soon as the cavity occurs, with its much-lower-than-ambient pressure, it collapses violently. This process is repeated rapidly with (a) much generation of noise, (b) loss of thrust (in the case of propellers), (c) markedly increased drag, and (d) gradual pitting and erosion of the surface where cavitation occurs.

The supercavitating propeller, rather than trying to eliminate cavitation, is designed to set up a permanent cavity—one that doesn't collapse. Next to eliminating cavitation altogether, this has proved to be a most satisfactory solution in all of the above respects.

The supercavitating propeller now under test at China Lake is not destined solely for torpedo use. In fact, its most promising future may be in hydrofoil and other high-speed surface craft. Deep-running submarines and the torpedoes they will be firing at each other operate at such a depth (and resulting high ambient water pressure) that cavitation is not a problem.

Seeing Eye.—Edo Corporation, College Point, N. Y., has developed a portable echo ranger for use by divers on salvage work or seeking lost objects under zero visibility in deep water. The unit carries its own batteries and is protected to depths of several hundred feet.

Hull Protection.—Navy's program for improving methods of cathodic hull protection is beginning to show results. Both zinc and magnesium anodes have been tested—with data now available on magnesium from Metallurgy Division, Physical Metallurgy Branch, U. S. Naval Research Laboratory, Washington, D. C. In summary form, the results are:

Magnesium anodes—either coated with plastic or uncoated—can be attached to the hulls of ships up to and including destroyers in such a manner as to provide protection for as much as three years. Special techniques of installation increase anode life and reduce current loss to hull adjacent to anode.

Underwater Fuel Dumps.—The Navy is looking forward to the day when it will have fuel for submarines and surface ships spotted strategically around the floors of the world's oceans. A 50,000-gallon (1,200-barrel) rubber tank planted on the bottom of the Gulf of Mexico for over four months last year has been retrieved and reported in good shape.

If present plans of the Bureau of Supplies and Accounts go through, farms of million-gallon (50,000-barrel) rubber tanks will someday play a major role in the logistic support of the Navy.

A major advantage of this concept is that the rubber tanks filled with liquid fuel would be virtually transparent to underwater shock—thus requiring a direct hit for their destruction. Further, even if one of the tanks were punctured, its contents would not burn in the sea-water environment.

As for delivery of the tanks, they could be towed underwater by submarines. Similar concepts are proposed for servicing ground troops in amphibious landings.

A test tank was manufactured by the U. S. Rubber Company, Mishawaka, Ind., which subcontracted some of the design work out to Hanna Construction Company, Houston, Tex.

Radar for Flying Fish.—Problems of useful radar data display for high-speed (40 knots and up) surface craft will be studied by the Raytheon Company, Waltham, Mass., on the Flying Fish—the first operational hydrofoil craft to operate in North America. A 64-foot, 60-passenger craft, Flying Fish is entering into regular passenger service between Bellingham, Wash., and Victoria, B. C.

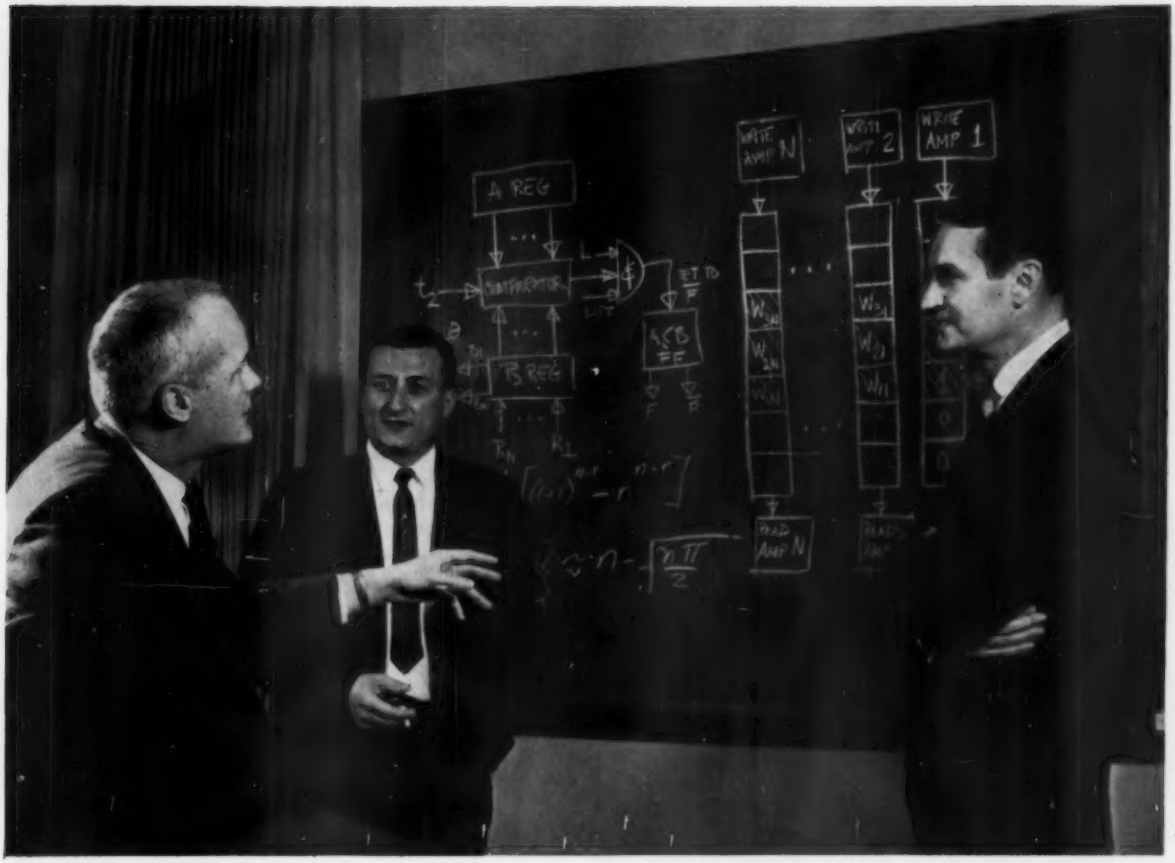
A principal study will be methods of presenting radar information to the pilot for rapid and easy reading while traveling at high speeds in congested waterways. Studies of the navigational, collision-avoidance, and data-display aspects of hydrofoil travel will benefit both commercial and military programs. Results should be applicable also to ground effect (air-cushion) vehicles—another front runner for the coastal ASW search-and-kill job.

Floating Missile Bases.—Aerojet-General Corporation's Aertron Division has proposed PROP (planetary rocket ocean platform) as a way to take the hazards to citizens out of launching very large space rockets—fueled with either nuclear or conventional fuels or both. PROP is a buoyant sea base for fabricating, assembling, static testing, and launching very large rockets.

The launching platform would be high enough above the sea to be beyond reach of even the highest waves and would be supported by an underwater buoyant structure far below wave forces.

Prior to a nuclear launching a submarine would evacuate personnel through an air lock. The rocket's exhaust would use the ocean surface as a blast shield. So far, PROP is just a proposal with

Mr. Hull is an experienced author and editor in the field of modern weapons including space and air power as well as undersea warfare.



Mr. R. J. Shank, President (right), with Dr. R. E. Fagen (center) and Dr. R. B. Dawson (left) of the Information Sciences Division.

A Report from American Systems Incorporated...

A New Organization for Advanced Systems Technology

American Systems Incorporated was launched a year ago for research and development in the electronic systems field. With an across-the-board interest in systems technology, the Corporation has formed five Divisions:

ELECTROMAGNETIC SYSTEMS

Electromagnetic physics; electronic and mechanical scanning antenna systems; development and manufacturing of special microwave components; design, development, and manufacturing of complete sensor systems.

COMMAND AND CONTROL SYSTEMS

Logic of command and control complexes; systems design and development; data acquisition, processing and display; communications.

COMPONENT DEVELOPMENT

Advanced component technology; materials and processes; computer component development; chemical deposition of magnetic materials on drums, disks, rods, tapes.

INFORMATION SCIENCES

Mathematical and statistical research; computer programming, and development of advanced programming systems; computation services; digital system studies; logical design of military and industrial systems; advanced systems analysis.

RESEARCH LABORATORIES

Solid state physics and systems; thin-film research and subsystems; components for information processing.

We are gratified that the past year has been one of significant growth. Operations were started in a leased 10,000-square-foot building. Recently, we moved into our own 27,000-square-foot plant, on a 13-acre site in Hawthorne, California. This plant, which is the first unit in a long-range building program, has custom technical and scientific facilities, including an ultraclean laboratory for thin-film developments and advanced devices research projects.

We are proud that we have been able to attract an outstanding staff of technical people. We believe that scientists and engineers are our primary resource, and it is to utilize this resource that we have founded this corporation. Our operating concept has been to establish an organization which both sought new ideas and provided the facilities in which the creative mind could also be a builder, seeing his ideas through to a practical product.

Qualified scientists and engineers who are interested and experienced in our fields of activity are encouraged to investigate career opportunities with American Systems.

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Underwater Ordnance (Contd.)

no takers in the form of customers. It is getting interested attention, however.

ASW Helicopter in Production.—The Navy's most powerful ASW helicopter has been ordered into production with the issuance of a contract to Sikorsky Aircraft Division of United Aircraft Corporation for twin-turbine HSS-2 helicopters.

This twin chopper boasts folding rotor blades for compact carrier stowage; a 4-hour patrol endurance with adequate emergency fuel reserves; amphibious landing capability; a speed of 162 knots at 6,000 feet; the latest sonar equipment; all-weather flight capability; automatic stabilization equipment; automatic navigation; deicing gear for engines, rotors, and windshields; radar; the latest in ASW weapons. In a word, it's got everything required to detect, identify, track, and destroy enemy submarines in any kind of weather.

Engines are General Electric CT-58 gas turbines. Other major suppliers are Bendix Corporation's Pacific Division, Ryan Aeronautical Company's Electronics Division, and Buehler Corporation's Indiana Gear Works Division.

New Cold for A-Subs.—Before long the refer (refrigerator) areas of nuclear submarines will be kept cool with thermoelectric refrigeration. Based on successful application of the Peltier effect to other cooling problems, the Navy Bureau of Ships has awarded a contract to Whirlpool Corporation's Research Laboratories at St. Joseph, Mich., to develop large systems for submarine food protection.

A-3 Polaris Test in 1961.—Lockheed Aircraft Corporation's Board Chairman Robert E. Gross says that test models of the 2,500-mile A-3 Polaris missile will be launched during 1961. That's way ahead of any previously stated dates. He also reported that the first model of the Navy's new ASW airplane, the P3V-1 will be in the air before summer.

Receivers for VLF Navigation.—As another step toward realization of its Omega long-range worldwide navigation system, the Navy has awarded a contract to I.T.&T. Laboratories, Nutley, N. J., to develop and build 20 receivers. Omega is a hyperbolic system, similar to Loran, based on very low frequency continuous-wave (CW) transmitted from fixed sites.

Receivers are used to measure the phase difference between different transmitted signals. Eight transmitting sites (each with a range of 5,000 miles) will be capable of servicing the entire globe and will enable aircraft and ships (including submarines) to get a fix accuracy of one mile.

Lithium and Sodium Fuels.—Theory says—according to W. D. White, Naval Ordnance Test Station, Pasadena, Calif., in an American Rocket Society Paper—that lithium fuel reacting with ingested sea water can result in a specific fuel consumption of 1.5 pounds of metallic lithium per shaft horsepower per hour.

Toward this end, the Navy has built a combustion chamber that gives 95 per cent combustion efficiency at 1,000 degrees Fahrenheit. Uses: High-speed underwater missiles (this ramjet type of engine is known as a hydroduct) and certain highly specialized surface craft.

Problems: Production of very fine lithium (or sodium) metal powder is still a tricky business. So is protection from oxidation and humidity during storage and shipment. Both metals are very reactive and, for metals, rather soft (sodium at room temperature can be cut with a jackknife with ease).

From Davy Jones' Locker

Problem in Pressure Tanks: Navy BuShips is looking for a 3,000-p.s.i. plastic air storage cylinder to reduce weight of gear Scuba divers must carry around with them.

Problems in High-Temperature Paint: BuShips wants a better paint for diesel exhaust mufflers, boiler uptakes, and snorkel exhaust visors. Paint has to withstand not only sea environment but severe thermal shock and prolonged temperatures of from 600 to 900 degrees Fahrenheit.

Problem in Underwater Drag: BuShips wants a material for coating underwater vehicles such as submarines and high-speed missiles (rocket or hydroduct-powered torpedoes) which will (a) result in reduced parasite drag, (b) provide corrosion protection to steel surfaces, (c) survive for long periods in the undersea environment, (d) reduce flow noise, (e) be applicable to large surfaces, and (f) if possible, have antifouling characteristics as well.

The Navy has such a covering now that has yielded startling drag reduction results in tow tests, but is not certain that the technique will be applicable to large bodies.

Problem in 300 KVA Static Inverter: To cut down noise generation and improve reliability under combat conditions, Navy wants a 300-KVA static inverter with no moving parts, vacuum tubes, or relays which will take d.c. current supplied by fuel cells or thermoelectric converters and supply large volumes of a.c. power for shipboard use. Specifications are as follows:

(a) Input: 175 to 355 volts d.c. (immediate need), and 7 to 20 volts (future need); (b) Output: 120 volts plus or minus 1 per cent, 60 or 400 cps. plus or minus 0.5 per cent, 3-phase, 80 per cent full load power factor; (c) Ambient temperature: 20 to 50 degrees centigrade; (d) Duty cycle: continuous; (e) Wave form: 10 per cent maximum total harmonics, 6 per cent maximum any single harmonic; (f) Overload capacity: 300 per cent for 2 seconds; (g) Life: 40,000 operating hours; (h) Cooling method: Convection or fresh water.

Problem in Ship's Lighting: The Navy Bureau of Ships wants a practical system of electroluminescent lighting to replace incandescent and fluorescent sources on board ship where space is limited. System should have a lumen-per-watt efficiency at least comparable to that of fluorescent lamps; 100 foot-lambert brightness; white color; minimum of 10,000-hour life; size and shape suitable for shipboard use; and good resistance to shock, vibration, temperature, humidity, etc.

Problem in Power: BuWeps wants a "simple, efficient, and practical" means for obtaining both a.c. and d.c. power from shafts rotating at 50,000 to 100,000 r.p.m. Use: Augment torpedo's battery pack by converting some of turbine's energy into auxiliary power.

Problem in High-Yield Batteries: BuShips wants a dry storage battery with a maximum diameter of 2.75 inches, maximum length of 5.0 inches, output of 250 watts at 12 volts for 18 minutes, rise time of 5 seconds, shelf life of 3 years, and activation by electrolyte injection on impact. Needed as primary reserve battery in countermeasure beacon.

Problem in Welding: BuShips wants a reliable welding process for HY80 steels that is fully automatic, fast, and does not add as much heat to the weld area as present methods. BuShips suggests submerged arc system might provide the answer.

Problem in Coaxial Cables: BuShips needs coaxial cables and shielded multiconductor cables that are: Nearly as flexible as unshielded cables, watertight along the cable axis so that end sealing is unnecessary, usable at pressures of 500 p.s.i. or more, and interference-free at low frequencies.

They also should also be capable of withstanding severe thermal and mechanical shock and temperatures down to minus 65 degrees Fahrenheit. Uses: Retractable submarine electronics. Navy says: There is nothing commercially available that is acceptable at this time.

Problem in Ocean Floor Mapping: BuShips wants a better system for determining slope pattern and ruggedness of ocean bottom. Need: Better 3-D maps of ocean bottom as aid to navigation with bottom-bounce sonar.

LIBRASCOPE COMPUTER FACILITIES

Shown below is a composite view of Librascope's facilities where a variety of computer systems are currently in different stages of design and production. Some are strategically involved with national defense...others deal with business and industrial process control. Each is uniquely designed to answer a particular need. The success of these systems illustrates the value of Librascope's engineering philosophy: A decentralized organization of specialized project teams responsible for assignments from concept to delivery...and backed up by excellent research, service, and production facilities. For your computer requirements, call on the company whose breadth of diversification in computer technology is unsurpassed. ■ Librascope Division, General Precision, Inc., 808 Western Avenue, Glendale, Calif. For career opportunities write to John Schmidt, Engineering Employment. ■

computers that pace man's expanding mind

ROCKETS AND GUIDED MISSILES

Alfred J. Zaehringer

Liquid Rockets

Reliability of liquid rockets for manned aircraft and for upper stages appears on the increase. The Aerojet-General Able engine system has had twenty-three successful flights. The lightweight engine using white inhibited fuming nitric acid and hydrazine-type fuel has helped to put ten of the fourteen U. S. satellites in orbit. With a thrust of 7,600 pounds, the total engine weight is 75 pounds. Tubular aluminum construction is widely used.

The up-and-coming Centaur rocket will use two LR115 engines by Pratt & Whitney. Each engine produces 15,000 pounds of thrust and has a performance 35 per cent greater than that of liquid oxygen-hydrocarbon engines now in use. The LR119 engine will be used on upper stages of the Saturn rocket. This engine uses liquid oxygen and liquid hydrogen, and firing times of 5½ minutes per engine have been accomplished.

The Bell Aerospace Agena engine uses storable propellants—fuming nitric acid and a hydrazine fuel. The XLR81-BA-9 engine is pump-fed and is capable of two restarts at altitude and also is capable of being moved to provide thrust-direction control.

The Thiokol XLR99-RM-1, rated at 50,000 pounds of thrust, is used on the X-15 aircraft. Able to operate under a wide range of environmental conditions, the engine is throttlable from 25,000 pounds to full thrust and can be restarted in flight. Using liquid oxygen and liquid ammonia, the engine has a duty cycle of one hour and 100 firings. It is expected to push the X-15 to new altitude and speed records in the near future.

Solid Rockets

The Blue Scout I, the Air Force version of the NASA Scout satellite rocket, made a long-range firing from Cape Canaveral recently. The rocket, a 3-stage job, reached a high point of 1,000 miles in its trajectory and impacted some 1,200 miles down range. The solid rocket carried over 300 pounds of instruments, 90 pounds of which separated from the rocket and rode in the nose cone which hit the Atlantic.

The Minuteman ICBM is slated soon for its first flight from Cape Canaveral where an underground silo launcher has been constructed for the test. The underground launch test program has been so successful, according to the Air Force, that only two-thirds of the tests originally called for were used, with the result that the entire program was accelerated.

The 3-stage ICBM uses a large composite-propellant, case-bonded grain. The first stage is 20 feet long and 5½ feet in diameter. Early launching tests were made in the Mojave desert from a silo eighty-four feet deep and with an inside diameter of twenty-eight feet. As a result of the launch from the pit, the maximum overpressure amounts to only some twelve psig. for about half a second.

Big boosters, using modular solid rockets, were advanced by Grand Central Rocket Company as a method for putting large payloads into orbit or for space studies. From 3 to 5 stages are suggested to put packages of 30,000 to 250,000 pounds into orbit and send 22,000 to 60,000 pounds to the moon. Launch vehicle weights would range from 2.471 million pounds to 13.830 million pounds. It is estimated that by using such techniques the U. S. could have a man on the moon by 1967.

Sounding Rockets

The U. S. Army Signal Missile Support Agency has revealed its contributions to the meteorological rocket network. During 1957 and 1958 the exploratory program included the firing of 7 Nike-Cajun rockets to 121-mile altitudes, 29 Loki I rockets to 28 miles, and 19 Loki II rockets to over 50 miles. The rocket network now can provide data to 200,000 feet in the North American area of the world.

The Navy has used the Hasp rocket for fleet determination of high-altitude conditions. Copper chaff has been used in the determinations to 100,000 feet. A new version will carry metallized plastic chaff to an altitude of 20,000 feet; it will be used to determine wind speed, direction, temperature, and pressure from peak altitudes down to 50,000 feet. The Hasp (high-altitude sounding projectile) is fired from Navy slow-fire 5-inch guns.

The Sandia Corporation, Albuquerque, N. Mex., has used the Arrow (a Loki-type rocket) and Deacon combination to send chaff to over 300,000 feet. Chaff also is expected to be ejected at altitudes of 425,000 feet. The falling chaff is tracked via radar and gives an idea of high-altitude winds.

Ozone exploration of the upper atmosphere has been carried out by the Office of Naval Research with Arcas-type rockets. Measurements of ozone content of the upper layers of the atmosphere are expected to contribute to knowledge of processes under way. The Arcas rocket, built by Atlantic Research Corporation, can carry payloads of 5 to 20 pounds to altitudes of up to 330,000 feet. A 2-stage version is now under development and will enable instruments to reach 420,000 feet. Over 400 flight tests of the rocket have been made. Production rate of the rocket is stated to be 100 a month.

Auxiliary Power

In addition to providing tremendous bursts of energy to lift our missiles and space craft from their pads, there has been a growing realization that the instruments, control and guidance mechanisms, and life-support systems for manned flight will need extensive research and development effort. For short-range missiles (and this is now for intercontinental distances), the problem ends with the impact of the craft. Total flight times are measured in terms of seconds and minutes. Batteries, or other chemical sources are called upon to supply power for guidance and control.

For satellites, reentry vehicles, and other interplanetary craft there will be no one type of auxiliary power system that can meet all needs. Power sources are: primary batteries, fuel cells, photovoltaic (solar cells), thermoelectric and thermionic conversion, and other solar systems. In all, the Air Force is spending $14 million on such energy research for fiscal year 1960.

Other areas of energy conversion include the nuclear methods and the relatively new field of magnetohydrodynamics (MHD). At a recent SAE meeting, MHD was advanced as a new vehicle-propulsion method. MHD devices are visualized for reciprocating drives, motors, brakes, and afterburners. All would be high-current, low-voltage devices.

Mr. Zaehringer, president of the American Rocket Company, Wyandotte, Mich., is a recognized authority on astronautics, guided missiles, and jet propulsion.

Compact air conditioning

for ground support use...

Trailer mounted refrigeration unit, 5 tons capacity

AIRESEARCH 400 cycle ac Freon ground air conditioners are the most reliable and compact systems produced for ground cooling applications. They are easily transportable by helicopter or ground vehicle to any field location.

The compact, fully automatic unit shown at left, for example, measures 5x5x2 ft, weighs only 550 lb and provides 7½ to 10 tons of cooling on a 125°F day. It also provides 90,000 Btu per hour heating.

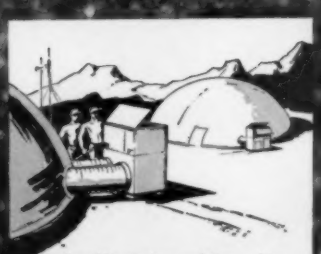
The heart of the system is a simple centrifugal Freon compressor which has only *one* moving part.

A hermetically sealed unit, it operates virtually without vibration and is unaffected by either attitude or oil level.

Essentially the same AiResearch air conditioning system used in today's jet airliners, these lightweight units have more than 500,000 hours of proven dependability.

Built to withstand rough handling in the field and operate dependably under the most severe weather conditions, rugged air conditioners of this same basic design are available, or can be built to provide from fractional tonnage up to any capacity of ground cooling desired.

• A brochure describing AiResearch ground air conditioning systems may be obtained by writing to Environmental Controls Project, Los Angeles Division.



Inflatable shelter refrigeration unit, 7½ tons capacity (unit shown above)

Helicopter transportable hut refrigeration unit, 1½ tons capacity

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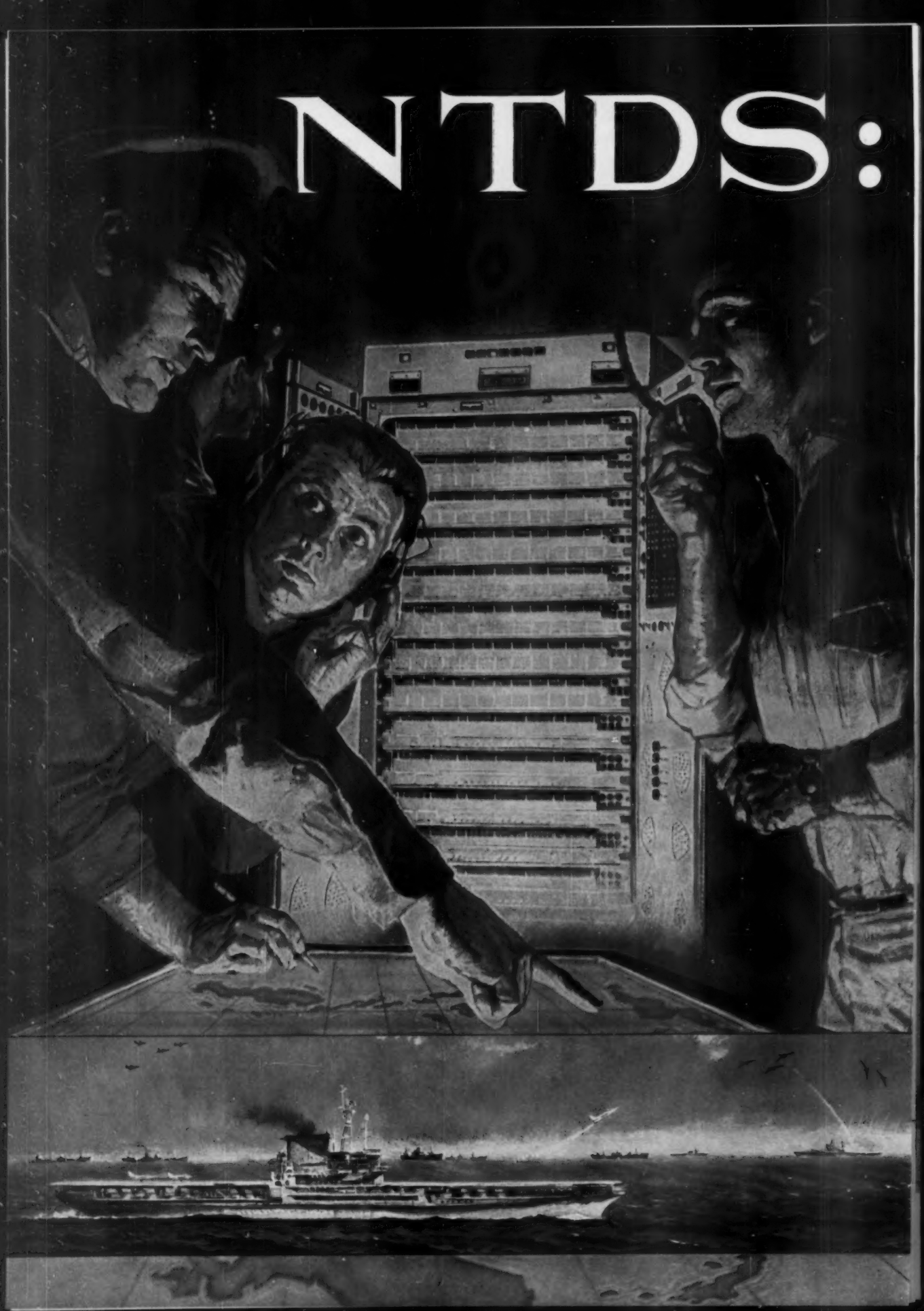

When Seconds count!

Seconds count in this day of space age weapons. They may mean the difference between victory and defeat.

As much as 10 years ago, the operational control of huge naval task forces and ships had already become too complex and too time consuming for rapid handling solely by humans. In 1953 Remington Rand Univac was selected to make a feasibility study on automatic data processing for naval tactical situations.

From this study came NTDS, Naval Tactical Data System, an automatic data processing system which collects, processes and evaluates naval tactical data and recommends courses of action in virtually "zero" time. "Heart" of NTDS is the AN/USQ-20 Univac Computer, ruggedized for the extreme environmental conditions inherent in shipboard operations and revolutionary in its extremely compact design. NTDS is an example of Univac's total system capability—the ability to define the problem, conduct the feasibility study, design the functional system, develop systems implementation, install and operate . . . and, then, to conduct continuation work.

For further information on Univac's total systems capabilities, call or write: Remington Rand Univac, Division of Sperry Rand Corporation.

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ARMAMENT ELECTRONICS

Traver B. Van Vliet

Frescan.—Modern missile-armed cruisers and destroyers of the U. S. fleet have been equipped with the first seaborne electronic scanning radar capable of pinpointing simultaneously three essential target dimensions—range, bearing, and altitude—to retaliate against enemy airborne attack.

The U. S. Navy and Hughes Aircraft Company announced that Frescan, a powerful, lightweight, all-weather radar, uses only a single antenna, transmitter, and receiver and automatically flashes information on supersonic targets to information and control centers which fire interception Talos, Terrier, or Tartar missiles.

Frescan concentrates all available power in sharp, pencil-shaped beams of energy to pinpoint targets at great distances and with extreme accuracy. Range and height data are obtained by electronic scanning in a vertical plane in milliseconds while rapid rotation of the antenna supplies target bearing.

Conventional radars require heavy mechanical gyrostabilization equipment above deck to keep the antenna platform level at all times. The Frescan antenna is affixed to the masthead and allowed to roll and pitch with the ship. Electronic stabilization assures accurate information no matter at what angle the antenna is located.

Roll and pitch signals from a ship's main gyro are supplied to a Hughes-developed computer which instantly and automatically modifies the elevation beam scanning program and presents the true position of targets on the radar scopes.

The Navy and Hughes pioneered the development of three-dimensional radar with the company delivering the first prototype equipment to the Bureau of Ships in August 1957. The frequency-scanning technique was developed after many years of basic research. The Frescan radar system is an example of joint service cooperation. A direct result of the Navy's pioneering effort is Frescanar, a U. S. Army 3-D electronic scanning radar. Frescanar serves as the "eyes" of Missile Monitor, a mobile air defense fire-distribution system for use with a field army, which is now deployed in Europe.

Ships now equipped with Frescan include the Navy's newest missile cruisers U.S.S. GALVESTON, SPRINGFIELD, and PROVIDENCE, the missile destroyer-leader DEWEY, and others.

Mr. Van Vliet is a student of engineering and mathematics. He is active in amateur radio and also in experimental electronics.

Solar Communications.—Tests of an experimental communication system employing sunlight were conducted by Electro-Optical Systems, Inc., under contract with the Air Force's Wright Air Development Division. The tests demonstrated the use of optical frequencies for long-range space communications. According to the company, ranges of at least 2 to 3 million miles are possible using this technique at a transmission rate of ten bits a second. By using larger transmitter mirrors, ranges could be increased to over 10 million miles.

Orbital Simulator.—The high-vacuum orbital simulator (Hivos), a gigantic test bed for satellites and spacecraft, is now under development at Lockheed Aircraft Corporation. The huge piece of test equipment will help tell what happens to space vehicles over long periods in orbit. It will be able to duplicate the heat absorbed from the searing radiation of the sun in space, and the freezing, near-absolute-zero cold of space in the earth's shadow.

The new facility will be used by Lockheed's Missiles and Space Division to test various satellites and spacecraft, primarily its Agena vehicle, under orbital conditions. The space chamber's operation will be automatically programmed and controlled. Hivos will have a low-speed digital data acquisition system for recording the thermal environment as well as monitoring vehicle functions.

Checkout equipment similar to that used in conventional earthly checkout of satellites will allow the satellite to be run electronically through its entire program under nearly actual space conditions. Twenty-two diffusion pumps plus eight "roughing and ejection" pumps will provide a vacuum near that of space.

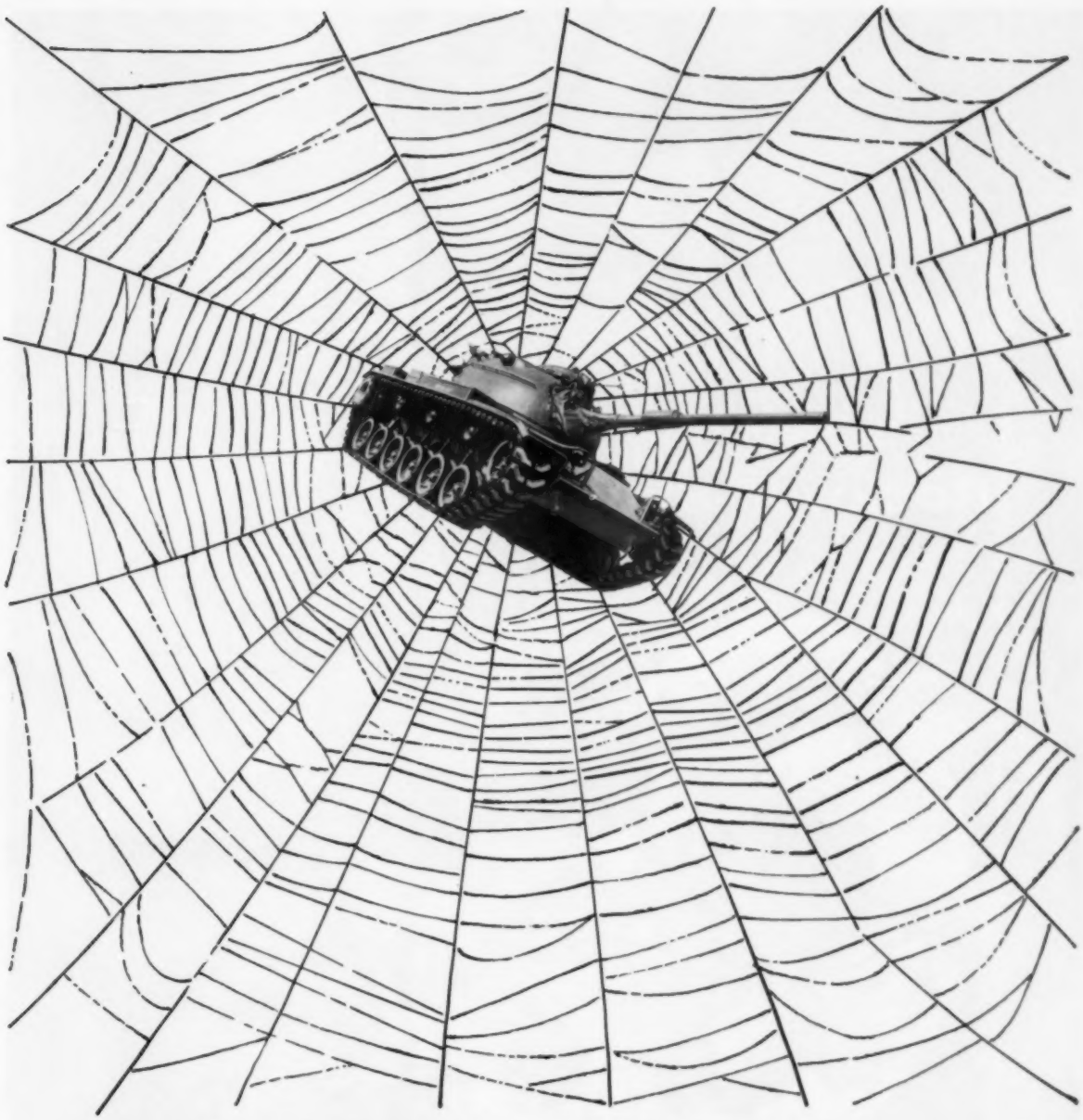
The sun's heat in space will be simulated by panels of quartz lamps located close to the outer surface of the satellite. Lamps will provide up to a maximum of 1,000 Btu of heat per square foot per hour. In addition, walls of the chamber will be cooled by liquid nitrogen, down as low as minus 320 degrees Fahrenheit. Completion of the simulator is scheduled for August 1961.

Magnetohydrodynamic Generator.—The National Aeronautics and Space Administration has awarded a contract for investigation of a magnetohydrodynamic power generator to Thompson Ramo Wooldridge Inc. The generator is based on the use of a hot plasma moving across a magnetic field inducing an electromotive force between two electrodes. According to the company the device could find use in a manned space vehicle as an intermediate-duration power source and to provide short bursts of high-power output.

Electrostatic Tape Camera.—An electrostatic tape camera recording images electrostatically on plastic tape is being developed for the National Aeronautics and Space Administration by Radio Corporation of America, for use in the Nimbus meteorological satellite. The image-recording technique combines a data-storage capacity comparable to that of photographic film with the versatility of magnetic tape—no chemical processing is required, and the image can be erased whenever desired. An operational model is expected to be ready shortly.

South African Tracking Station.—The United States has signed a bilateral agreement with the Union of South Africa for location of a tracking system in Western Transvaal. The station, which will have an initial range of 4 million miles, will have an 85-foot parabolic tracking antenna mounted on a 100-foot pedestal. The tracking stations will be part of a network to include stations in Australia and California. Completion of the station is scheduled for early 1962.

VHF Scatter.—Tropospheric scatter communications at stations in Greenland and Nova Scotia will be studied by the Federal Aviation Agency in tests to determine the feasibility of using VHF scatter communications over the North Atlantic. The studies are aimed at lowering congestion in the HF band and to increase communications reliability. In conjunction with a Pan American World Airways station in Ireland, the two stations would provide VHF coverage over most North Atlantic air routes.



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Rockwell-Standard is the largest manufacturer of standard military and commercial trailer axles. These include a complete family of axles in a wide range of capacities, both single and tandem.

Rockwell-Standard military and commercial trailer axles are produced in the world's largest, most modern trailer axle plant. Here unmatched production, research, and testing facilities are combined with many years of axle building experience to offer military vehicle manufacturers service that gets results.

Because of the completeness of the Rockwell-Standard line, we are able to adapt our designs to most special applications. We welcome the opportunity to quote on all trailer axle needs

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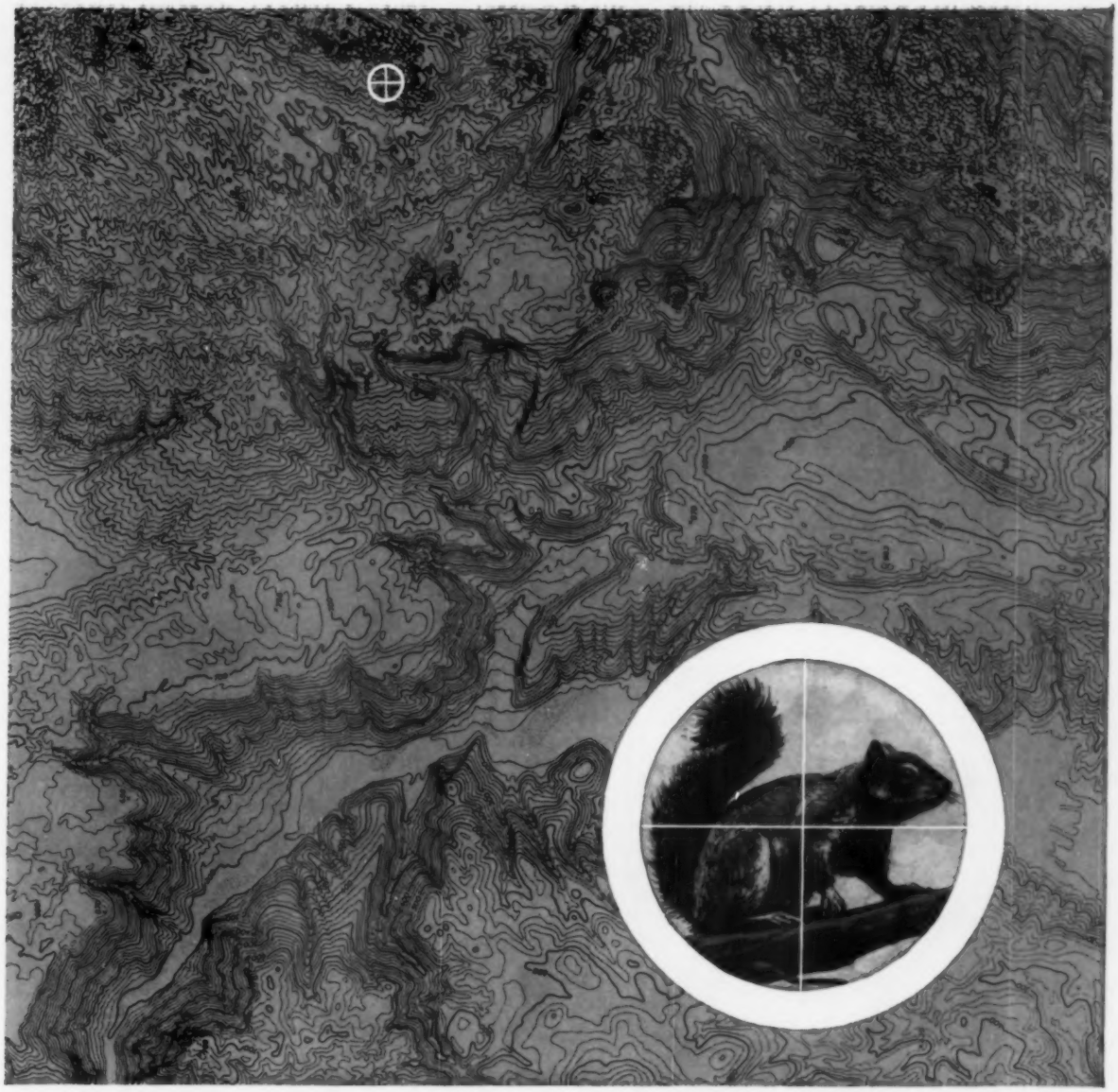


How would you drop a squirrel at 1,000 yards?

The Budd Company's fin-stabilized ammunition can drop a squirrel at 1,000 yards. Now, of course, this ammo is not for squirrel hunters—but it does illustrate the success Budd has had in developing accuracy.

The Budd Company has complete facilities—and experienced engineers—for the design, development, prototype-manufacture, and testing of ammunition and explosives for the Ordnance Corps, including a test-firing range at Indiantown Gap Military Reservation near Harrisburg, Penna.

With over a decade of experience in this highly specialized art, we are prepared to solve your ammunition or other explosive ordnance problems. Product Development Department, The Budd Company, Philadelphia 32, Pa.

PRODUCT Budd DEVELOPMENT

MATERIALS PROGRESS

George S. Brady

High-Temperature Ceramics.—Research on ceramics for high-temperature parts is going forward at a rapid pace. High alloys will continue to have a definite place, especially for wire and sheet where workability is needed, but high alloys usually contain large percentages of nickel and cobalt, and these "strategic" metals are likely to be scarce in a war emergency. In general, ceramic parts have higher heat and erosion resistance than metals, but so far they lack the necessary flexural strength for many uses.

A typical high alloy that is readily workable into complex parts is the improved Alloy 56 of the *Haynes Stellite Company*. Its nominal composition is: 21 per cent chromium, 13 nickel, 11.5 cobalt, 4.5 molybdenum, 1.5 tungsten, 1.5 manganese, 1 silicon, 0.75 columbium plus tantalum, 0.10 nitrogen, 0.30 carbon, and the balance iron.

The melting range is 2,325 to 2,500 degrees Fahrenheit, and it has high resistance to oxidation at 1,900 degrees, retaining a strength at elevated temperatures superior to that of stainless steel. At 1,600 degrees its tensile strength is 44,000 pounds per square inch, and at 2,000 degrees it still has a strength above 15,000 pounds.

An improved version of Superalloy WI-52 has very little nickel, but it contains more than 60 per cent of the scarcer cobalt. Its oxidation resistance is high, and it retains good strength at moderately high temperatures, but its tensile strength drops to below 15,000 pounds at temperatures around 1,800 degrees. These high alloys have their uses, but if jet aircraft and missiles were to go into high production in a time of emergency there might be acute supply difficulties with the scarcer metals. Nor do they give the required strength in the temperature ranges above 2,200 degrees.

An executive of the Federal Aviation Agency was recently reported as saying that the materials needed to catch up with projected designs "have not yet been invented." He was not referring merely to high-temperature materials, but this problem of high temperature is high on most research programs. No one group of materials will furnish the complete answer.

In the case of ceramics, it is best not to consider them as "substitutes" for metals, but rather to look upon them as a separate group of materials having their own individual characteristics to be used separately or in combination with metals, usually as ceramic coatings, to suit the immediate need.

Refractory Hard Metals.—There is another relatively new group of intermetallic compounds, the "refractory hard metals," offering great promise for parts of extremely high heat and erosion resistance. Although very ceramiclike, they are not ceramics, and, although usually containing only metal atoms, they are not alloys but are true chemical compounds.

The borides and aluminides all have good service temperatures well above 2,200 degrees, and, although some are very brittle, in general the rupture strength and heat-shock resistance are superior to ceramics. These materials are really not new, but much basic research is still needed for the production of strong parts. They come as fine hard powders, sometimes in various crystal phases, and are compacted into parts either with or without a metal binder.

National Carbon Company, a division of the *Union Carbide Corporation*, is now offering a titanium diboride powder, TiB_2, which can be compacted without binder into parts of high hardness, 3,300 Knoop, which have a flexural strength of 35,000 pounds per square inch and are resistant to oxidation well above 2,000 degrees Fahrenheit.

Inert to molten aluminum and having high electrical resistivity, this material has been found suitable for lead-in connections for aluminum cells to reduce power losses. It also is being recommended for shear blades for cutting plastics containing abrasive fillers, as well as for making lathe tools for cutting hard metals at high speeds.

The *Electro-Chemical Division*, of the *Norton Company*, Niagara Falls, Ontario, now has a wide range of ceramic and intermetallic-compound powders for application as refractory coatings by the plasma-arc torch method which gives a more adherent and stronger bond than by vapor depositing or spraying. The powders include borides of chromium, molybdenum, titanium, vanadium, and zirconium, and the carbides of boron, chromium, titanium, and zirconium.

Included in a series of refractory coatings under development at the *Battelle Memorial Institute*, Columbus, Ohio, especially intended for resistors and other electronic elements, is a chromium-titanium nitride. The material has a slate-gray color and has good adhesion to glass and other ceramics as well as to metals. The coating is hard, abrasion resistant, and stable at high temperatures.

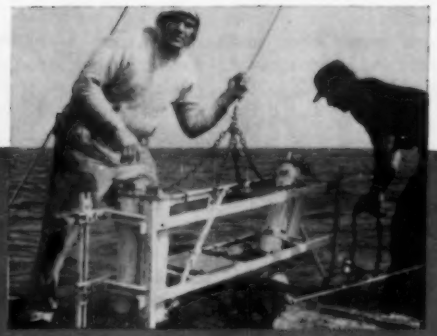
Progress with Rare Metals.—Possibilities of obtaining parts for very high temperature use from single metals of the so-called rare-metal group are indicated by recent experiments with pressed hafnium powder at the *Lewis Research Center* of the National Aeronautics and Space Administration. The 325-mesh powder was compacted at high temperature and pressure to yield parts with 98 per cent theoretical density without grain growth. This metal is costly, but has a melting point around 4,000 degrees Fahrenheit.

Hafnium oxide, or hafnia, is a better refractory ceramic than zirconia but is costly. The inversion of the crystal phase from monoclinic to tetragonal occurs at 3,100 degrees with an expansion of only 3.4 per cent, compared with 2,000 degrees and an expansion of 7.5 per cent in zirconia.

Shipboard Tanks.—The 551-foot, 16,625-deadweight-ton tanker LELAND DOAN, being built at the Quincy shipyard of the *Bethlehem Steel Company*, has four nickel-clad steel tanks and one plastic-lined tank, with a total capacity of 3,690,000 gallons. It is adaptable for carrying a wide range of chemicals. The hull of a 65-foot all-aluminum passenger boat built by the *Chaffee Machine Company*, San Diego, Calif., was constructed upside down so that the flat plates of aluminum alloy 5086 could be easily formed and welded into position. About 15 tons of aluminum alloy (Kaiser 5086) were used in the boat.

It was erroneously stated in this department in the January-February issue that the flight deck of the nuclear-powered U.S.S. ENTERPRISE was made of aluminum. However, the hangar-to-flight-deck

Colonel Brady is a consulting engineer, author, and editor, Washington, D. C. He is a well-known authority in the field of materials, and his "Materials Handbook" is a recognized source of information on the subject.



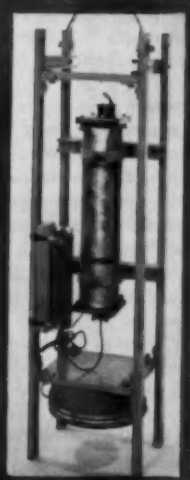
PROVEN IN OCEAN DEPTHS MORE THAN 5 MILES DOWN

▼ **Automatic Underwater Photography Systems.** This automatic oceanographic photography system has been used at depths to 27,000 ft. and is test-proven for use at the ultimate ocean depths.

Powered by self-contained batteries, the unit needs no electrical cables to the surface.

A camera-mounted sonar pinger is used to position the camera at the proper distance above the ocean floor. Once the camera unit has been positioned, photography is automatic and two cameras make stereo pairs of photographs on 35 mm. film every 12 seconds for 100 minutes using an integrated electronic flash for illumination. Depth, pressure, time, location, date and ship identification data are automatically logged with each exposure. Two models are available: CA-9 for use in depths to 37,500 ft. and CA-8 for depths to 6,500 ft. For complete specifications, write for Data Sheet #2000

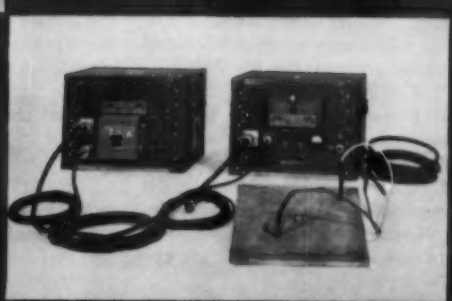
▼ **Sonar Pinger.** This battery-powered device is finding ever increasing applications in oceanography.



The unit will run for over 16 hours on one charge giving out one 12 kc ping per second at an accurately timed rate. This precise timing allows a recorder on the ship above to be synchronized to the pings. By comparing the time of arrival of the direct pings with that of the bottom reflected pings the distance from the pinger to the ocean bottom is shown.

Sonar Pingers are used in positioning oceanographic instruments such as underwater cameras, coring tools, water sampling bottles, etc. . . . and in making detailed bathymetric surveys of the ocean floor. Write for Data Sheet #3000.

▼ **Sonar Thumper — A new, high intensity underwater sound source.** This electronic device was developed primarily for making marine seismic surveys. It emits a high intensity "thump" underwater at a rate of up to 2 per second. The echoes of the "thump" show not only the water depth, but the geological structure of the bottom. This information is invaluable to those making underwater constructions, such as missile launching platforms, transducer arrays, breakwaters, tunnels and bridges. The unit delivers a clean, highly consistent pressure waveform.



Additional applications include underwater sound transmission studies, missile impact simulation and navigational applications. Complete specifications on request.

E&G

Edgerton, Germeshausen & Grier, Inc.

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elevators are mainly of aluminum. While the Navy has been seeking to reduce weight by the use of light metals, there is no apparent trend to displace steel where strength is needed.

Silica Glass Shields.—Cylindrical shields made of 96 per cent silica glass, with a wall thickness of ⅛-inch, are used to surround the capsule radio antennas for sending rocket signals back to earth. The high-silica glass is transparent to radio signals, and protects the capsules from heat and from thermal shock up to 900 degrees Fahrenheit and a possible reentry temperature of 2,200 degrees. The shields are produced by the *Corning Glass Works*, Corning, N. Y.

Corrosion-Resistant "Steel."—A new type of high-temperature, corrosion-resistant "steel," developed at the *Ford Motor Company* laboratories, contains no nickel or chromium, has higher strength than ordinary stainless steels, and is superior to 18-8 stainless steels in resistance to sulphur action at high temperatures. It also has superior oxidation resistance up to 1,400 degrees Fahrenheit. A typical analysis is given as: 30 per cent manganese, 8 aluminum, 1 silicon, 1 carbon, and the balance iron.

When cold-rolled and heat-aged it can be brought up to a tensile strength of 300,000 pounds per square inch, and a yield strength of 290,000 pounds. Like the chromium-manganese stainless steels, it work-hardens rapidly, requiring heavy pressures and intermediate annealing for forming.

Explosive Forming.—As for the forming of hard and tough metals, large savings in time and in the cost of dies are now being made by the use of explosive forming. The Rocketdyne Division of *North American Aviation, Inc.*, Canoga Park, Calif., reports a cost saving of half a million dollars in the dies for forming the bulkhead stiffeners for the B-70 airplane. The stainless-steel thrust chambers for the Drone rocket engine are also explosive-formed, and missile thrust chamber tubes of nickel and 20CB steel are formed in this way. The process is not being confined to the forming of hard metals. Missile pylons for the B-52 bombers, of aluminum alloy 6061-T4, are also explosive-formed.

New Enameling Process.—The *A. O. Smith Company*, Milwaukee, Wis., has a process for enameling steel without the use of the usual cobalt ground coat, and it gives an adherent protective coating on ordinary carbon steel so that it is not necessary to use the conventional enameling iron. The steel is coated with a combination of nickelous oxide, silica, and barium metaphosphate, and is then sprayed with the glass slurry and fired in the usual way.

Solar Batteries.—Although the solar energy converter, or "solar battery," has been glamourized in popular press articles as a great future source of plentiful, cheap power, electronic engineers working on the problem indicate that much research is still needed before these "batteries" can have widespread application. As presently made with silicon wafers, a 10-kilowatt solar generator would take up a space of 900 square feet.

Figures given indicate a possible output of three watts per pound for the bare crystal but an output of no more than one watt per pound for the assembled packaged converter, or half a ton per kilowatt. Present efficiency is stated to be less than 14 per cent, but it is hoped to increase this efficiency to 40 per cent.

Gallium arsenide and other types of crystals also are being tested. As the active region of a crystal is only a few millionths of an inch, it also is possible to use only thin films.

New Thermocouple.—A new thermocouple developed by *Englehard Industries, Inc.*, Newark, N. J., to give reliable service in a temperature operating range from 350 to 1,260 degrees Fahrenheit in turbojet engines, has one wire of the couple made of a gold-palladium-platinum alloy, and the other wire of a gold-palladium alloy. The consumption of the platinum-group metals for important industrial uses has been increasing steadily, and the trend indicates a total use in 1961 of about 800,000 troy ounces.

The biggest defense-related uses are for catalysts, crucibles, laboratory ware, electrical contacts, and spinnerettes. Englehard reports, however, that most of the metal is now being recovered, forming a continuous recirculating supply, so that the amount of new metal needed annually for industrial nonjewelry uses is relatively small.

Aluminum Pipe.—Aluminum piping was used for the first time in oil-well drilling by the *Shell Oil Company* in Texas. The light weight permitted extension down to 30 per cent greater depth than with steel pipe. Other advantages are reduction in labor costs and greater corrosion resistance. Alloy 6063-T6, heavy-end, 4-inch aluminum pipe also has recently been used to replace galvanized steel pipe as processing piping in the Texas fields. It cost $10 more per hundred feet, delivered, than the steel pipe, but the reduced handling and installation costs equalized this differential, and it is expected to give longer life.

For oil transport across desert areas where there is much corrosion from moisture condensation at night and much erosion of painted surfaces from sand storms, aluminum pipe has been found to be superior to steel pipe, requiring no maintenance painting. An aluminum pipeline also was used for oil transport under the brackish water of Lake Maracaibo, Venezuela.

In the chemicals-processing industries, aluminum piping is now being substituted for alloy steels for handling many chemicals. For some chemicals it is better than stainless steels, but its maximum operating temperature is limited to 400 degrees Fahrenheit, compared with 650 for carbon steel. The aluminum alloys used are 3003, 6061, and 6063.

Plastic Pipe.—Where operating temperatures are not high, plastic piping is becoming standard. The W. R. Grace & Company plant at Owensboro, Ky., replaced stainless-steel piping with Hi-Mol linear polyethylene pipe (*Carbon Products Corporation*, Cleveland, Ohio), for handling butadiene-styrene latex and acetate emulsions. Besides ease of installation and repair, the smooth bore of plastic pipe generally cuts down friction and eliminates clogging. American Agricultural Chemicals Company's plant at Danville, Ill., installed polyvinyl chloride piping for handling hot (120 degrees Fahrenheit) hydrofluosilicic acid which is very corrosive to plain or glass-lined metals, and no deterioration has been apparent.

Polyvinyl chloride pipe (Koroseal PVC of *B. F. Goodrich*), in a variety of sizes from ½ to 8 inches, is also being used at the plant of the Kermac Nuclear Fuels Corporation, Grants, N. Mex., to handle a number of corrosive chemicals, including hot sulphuric acid. For chemical plant installations. *Vanton Pump & Equipment Corporation*, Hillside, N. J., is now producing all-polypropylene gate valves in sizes one-half to two inches, which are resistant to solvents and chemicals at 185 degrees Fahrenheit. *Plastiline, Inc.*, White Plains, N. Y., has a full line of fittings for plastic pipe up to four inches made of high-strength nylon.

New Magnetic Material.—*Du Pont* engineers have developed a chromium-manganese-antimonide material that is nonmagnetic below 250 degrees centigrade and magnetic above that temperature. Most magnetic materials are the reverse of this, losing magnetism as the temperature increases. In this compound it is stated that the distance between the atoms is less than that which determines the line-up of magnetic forces, but with increased temperature the atomic distances are greater and the forces swing into a magnetic pattern. By varying the composition, the critical temperature of magnetism can be altered.

Book REVIEWS

Reviews in this issue by:

LOREN E. BOLLINGER, *aeronautical engineer, assistant professor, Ohio State University, Columbus, Ohio.*

COL. GEORGE S. BRADY, *consulting engineer, author, editor, Washington, D. C.*

D. S. DUNCAN, *editorial staff,* ORDNANCE *magazine, Washington, D. C.*

DR. JAMES B. EDSON, *senior assistant for missiles and space, Office, Assistant Chief of Staff, Army Intelligence, Washington, D. C.*

STANLEY FALK, *historian, Office, Chief of Military History, United States Army, Washington, D. C.*

PETER P. GILLIS, *machine design instructor, engineering consultant, Bristol, R. I.*

F. W. FOSTER GLEASON, *military historian, ordnance analyst, editor, Washington, D. C.*

COL. VIRGIL NEY, *writer, educator, military historian, Silver Spring, Md.*

W. H. RUSSELL, *educator, historian, Annapolis, Md.*

COL. HENRY C. THAYER, *ordnance management engineer, logistician, Washington, D. C.*

World Polity: A Yearbook of Studies in International Law and Organization. Vol. II. By the Institute of World Polity, Georgetown University, Washington, D. C. Utrecht/ Antwerp, Belgium: Spectrum Publishers. (U. S. distributor: Georgetown University Book Store, Washington 7, D. C.) 414 pp. $8.

THE Institute presents in its 1960 yearbook three papers concerning modern war, a study of the laws of land warfare during the American Revolution, and a bibliography of recent works on the laws of war.

The first paper, "The Nature of Contemporary Conflict," by William H. Roberts, J.U.D., Department of Political Science, Catholic University of America, presents an analysis of the basic causes of conflict in the world today. The author emphasizes the lack of common values between the free world and the Communist countries and the fact that neither force has the necessary power to establish a *Pax Universalis,* a modern extension of the *Pax Romana.*

Dr. William V. O'Brien, chairman of the Institute and associate professor of government, Georgetown University, in his article, "Legitimate Military Necessity in Nuclear War," deplores the lack of serious effort to develop a law of nuclear warfare.

Lieut. Comdr. William H. Barnes, III, U.S.N., in his paper, "Submarine Warfare and International Law," discusses the history of submarines, their growing importance to the fleets, and their status as a result of international conferences.

The fourth paper presents a marked change of pace as Dr. Martin J. Clancy, assistant professor of political science, Marquette University, discusses "Rules of Land Warfare during the War of the American Revolution" based upon correspondence, diaries, memoirs, and other papers. (*Continued on p. 708*)

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DEPARTMENT OF THE NAVY

A.O.A. DIRECTORY AND INDEX

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- **The Index to Volume XLIV of ORDNANCE also is available. It is arranged alphabetically by subject and author with title page for binding and covers issues No. 235 (July-August 1959) to No. 240 (May-June 1960) inclusive.**

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Book Reviews (Contd.)

In the final paper, Jean-Robert Legueу-Feilleux, teaching fellow in international law, Georgetown University, presents "The Law of War: A Bibliography, 1945-1958." This lengthy, 95-page list of legal works on warfare includes titles from many nations of the free world.—H. C. THAYER.

The Ultimate Decision: The President as Commander in Chief. Edited by Ernest R. May. New York: George Braziller, Inc. 290 pp. $6.

WHAT has been the American experience with wartime Presidents acting under their constitutional mandate as Commander in Chief of the armed forces? What powers have these Chief Executives wielded in this role? What was their origin and how may they be applied in the future? These are the problems that Ernest R. May and his collaborators examine in this short but informative and stimulating volume.

With an illuminating introduction and provocative conclusion by Professor May (who also wrote two of the other essays), the authors examine one by one the records of Madison, Polk, Lincoln, McKinley, Wilson, F.D.R., and Truman in their dual roles of civilian president and military commander. Not all our Chief Executives emerge covered with glory, but each made important contributions to the development of this aspect of the Presidency, and some showed an excellent grasp of the principles of war.—STANLEY L. FALK.

The Compact History of the Civil War. By Cols. R. Ernest and Trevor N. Dupuy. New York: Hawthorn Books, Inc. 445 pp. $6.75.

THIS father-and-son team is composed of two Regular officers whose long writing and military experience admirably combine to accomplish the task of comprising in one volume the story of the four years of America's mighty conflict. By their succinct style, they have done just that, and done it with considerable drama.

The military, the naval, and the political aspects of the war are well covered, not merely by the record, but by a wealth of pithy comment which is both objective and accurate. Strategy, logistics, and leadership (or the lack of it) are excellently handled, and much refreshing re-evaluation is a noteworthy feature. A keen sense of geography is present and is aided by forty excellent maps of battles and campaigns. The treatment of the naval story is exceptionally full.

There is but one serious flaw in the book. Readers of ORDNANCE will doubtless guess it—ordnance. Treatment of weapons is not only very sparse (a 4-page appendix plus an occasional reference in the general text) but often misleading. With this sole exception, the authors have presented us with a book of great historical value and much interest.—F. W. FOSTER GLEASON.

The Fight for the Sea. By Comdr. David D. Lewis. New York: World Publishing Company. 350 pp. $6.

HERE is a good example of a new kind of book. It is a study in depth, focusing upon a single aspect of warfare, wherein the author uses a summary of yesterday's experience to fix his readers' attention upon tomorrow's problems.

Specifically, Commander Lewis deals with antisubmarine warfare. His summary of its history is concise, readable, and backed by a thorough bibliography that alone is worth the price of the book.

The author devotes some 80 pages to World War I and about 200 pages to World War II. Here he presents a wealth of anecdotal narrative that will delight destroyermen and inform all who have never belonged to that wonderful fraternity.

Soviet military leaders are confident that if war comes it will be a long one wherein (among other things) the submarine will be the capital ship in a decisive struggle to control the sea.

In such a situation, Commander Lewis concludes, we can scarcely afford to neglect ASW as it was neglected before the two great wars of our century. If one will accept Commander Lewis' premise, his conclusion is inescapable.—W. H. RUSSELL.

On Thermonuclear War. By Herman Kahn. Princeton: Princeton University Press. 651 pp. $10.

THIS is not a book on thermonuclear weapons, but rather a political-strategical analysis of their capabilities, possible uses, effects, and possible deterrents. Part I, based on three "briefing" lectures, contains twelve chapters on such subjects as "Alternate National Strategies," "Conflicting Objectives," and "Will the Survivors Envy the Dead?"

A chapter on "The Real Past" is historic, showing how some wars have been precipitated by minor causes even when all parties concerned did not want war. Part II has five chapters on policy formation and proposals for defense programs.

One does not have to read far in the book to see that the publishers are correct in saying that Dr. Kahn's "briefings" to military and civilian groups "have caused controversy." It is evident that the world has not yet arrived at a solution to the problem, and it would be presumptuous for this reviewer to believe that he could give a final verdict on the complex arguments in the book.

The author is a scientist, but, although tending to a laborious prolixity, he offers a goal that seems quite reasonable in a world that some consider on the verge of military insanity. Sifting the verbosity, the reader arrives at the conclusion that the only solution is a "tactical offensive," that is, a known striking power of such might that it will be a deterrent against attack. However, this offensive position must not appear so "offensive" that it will look provoking and cause a possible enemy to loose a preemptive war. The book is worth careful study.—GEORGE S. BRADY.

Okinawa: The Last Battle. By Roy E. Appleman, James M. Burns, Russell A. Gugeler, and John Stevens. Rutland, Vt.: Charles E. Tuttle Company. 527 pp. $7.50.

THIS handsome, well-printed volume is a fine example of how a government publication may be republished as a civilian venture and at the same time not lose the authenticity and the tight documentation which mark the original 1948 edition by the Historical Division, Department of the Army.

Based upon the on-the-ground combat-historian techniques of World War II, this volume is a most accurate and detailed accounting of every phase of the combat on Okinawa. There is something on every page to intrigue the military professional or the layman who is interested in finding out how one of the Pacific's toughest battles was carried to complete and decisive defeat of a fanatical and hard-fighting enemy.

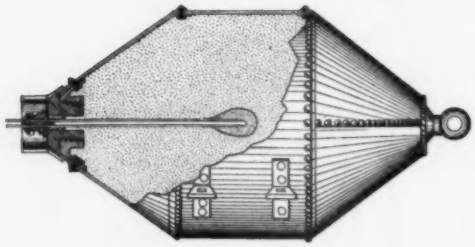
Operation Iceberg, as the plan for the Okinawa Campaign was officially designated, is complete within the covers of this work—the tables, maps, charts, and appendices. Vivid combat photos also help to make this an outstanding example of modern military history reporting. Of especial interest is the fact that several of the historians involved have since become well-known writers in the more prosaic fields of scholarship and literature. Sgt. James M. Burns of Okinawa is better known now as Professor James McGregor Burns, biographer of President Kennedy. Captain Edmund Love gained later fame as the author of a best-seller—"War is a Private Affair."—VIRGIL NEY.

Elements of Flight Propulsion. By Joseph V. Foa. New York: John Wiley and Sons, Inc. 445 pp. $12.50.

THIS technical book deviates considerably from conventional volumes on flight propulsion. Mr. Foa devotes almost as much effort to nonsteady propulsive flows as he does to steady processes. This trend is very desirable.

A sizable portion of the presentation

No. 3 in the series of A.O.A. monographs on Civil War armament



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A knowledge of naval weapons of the Civil War is of basic importance in the study of particular battles as well as the final outcome of that conflict.

This précis contains innumerable facts and statistics—heretofore not readily available to the Civil War student—on the naval guns, ammunition, torpedoes, and mines used by both the North and the South. Included are 20 illustrations, plus charts giving the characteristics of naval guns used, and ships sunk or damaged by torpedoes during the War Between the States.

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is original or is presented in a new manner. After starting with the basic ideas, the author leads into one-dimensional approximations, propagation of disturbances, and one-dimensional steady flow.

Analyses of nonsteady flows and nonuniform flows follow together with presentations on diffusers, nozzles, dynamic flow machines, pressure exchange, and combustion chambers.

He concludes with chapters on steady-flow and nonsteady-flow thrust generators. Much of the information in the latter section generally has not been available without recourse to individual papers and reports.

This book, highly recommended, will find a niche in the bookshelves of propulsion engineers because of the originality and importance of the material presented. —LOREN E. BOLLINGER.

Reaching for the Stars. By Erik Bergaust. New York: Doubleday & Company. 407 pp. $4.95.

TODAY we are living in the beginning of an age that, for great deeds in the face of great difficulties, has no parallel. The tales of men and of events in the predawn of astronautics are prelude to an epic whose unfolding grandeur will be unique in human history. Erik Bergaust has taken many stirring events of this predawn and woven them around the strong, bold career of Wernher von Braun. Many of the stories have appeared before, but they deserve the retelling. And some are new, being accounts of the author's own long-time contacts with the men, the techniques, and the politics involved.

The book covers Von Braun's formative years, his early work in German "amateur" rocketry, his support by the German and then by the U. S. military, and, finally, the turbulent events that transferred him and his group to NASA.

The book also shows with cruel clarity the capacity for power seeking, for lack of vision, and for destructiveness that men can display. It ill becomes the nations that visions of the great and good go begging, while our most strenuous exertions build monuments to greed and fear. It is sad that mankind must light its pathway to the stars with the glare of burning cities, but it is proving to be so.—J. B. EDSON.

Subsunk—The Story of Submarine Escape. By Capt. W. O. Shelford, R.N. New York: Doubleday & Company. 256 pp. $4.50.

"SUBSUNK" is the code word for a search and rescue plan executed—under British doctrine—whenever a submarine is one hour late reporting a scheduled surfacing. The very interesting book bearing this title is an account of nearly every known attempted rescue or escape from sunken submarines. In addition, the changes of Admiralty policy for this contingency are carefully followed from World War I to the present.

Submariners of many nations have shown valor and courage, bravery and ingenuity, in escaping watery coffins, and their exploits are inspiring as well as exciting. Intrepid salvage officers have been the heroes of the more successful rescues. However, the British Navy today believes that a sinking in circumstances permitting salvage operations soon enough to save lives would be fortuitous and has adopted a sole policy of individual escape.

The American Navy, largely because of the success of the submarine rescue bell when the SQUALUS sunk and the subsequent good safety record of American submarines, still maintains submarine rescue vessels equipped with the bell in addition to providing training and means for individual escape.—PETER P. GILLIS.

The Army Blue Book. The Navy Blue Book. The Air Force Blue Book. Each edited by Tom Compere. New York: Military Publishing Institute, Inc. 352, 376, and 376 pp. respectively. $1.50 per volume, $4.50 per set, paperbound; $4.95 per volume, $12.50 per set, hard cover.

THE Army, Navy, and Air Force are portrayed in detail in this trilogy of useful handbooks.

Edited by Tom Compere, president of the Military Publishing Institute, each volume is designed to present articles on historic events, current activities, and forecasts of the future. More than thirty such articles are contained in each volume.

A second section in each volume contains more than a hundred pages of facts about the service, and, finally, a brief synoptic service history. These facts include everything from insignia of rank and pay tables to the names of commanders of major forces. Many of the weapons, service leaders, and service activities are pictured.

The editors of the Military Publishing Institute propose to publish these volumes annually. Remembering the many changes that take place among service personnel each year, these Blue Books with their easy accessibility to factual service information should prove valuable.—H. C. THAYER.

The Foxes of the Desert. By Paul Carell. Translated by Mervyn Savil. New York: E. P. Dutton Company. 370 pp. $5.95.

ONCE again the sands of Africa come alive with the sounds of battle which lasted from September 1940 to May 1943 as the elite Afrika Korps with its elusive commander, Field Marshal Erwin Rommel, swept across its barren wastelands.

This tale has been told many times both by the British and by the Italians with their bitter memories and unrelieved defeats, but this version is the story of the "Bengazi Harriers" written by a German journalist. It gives an inner history of the Korps explaining the reason it was able to turn casually recruited units into formidable forces with the ability to become outstanding desert fighters.

The author's well-illustrated account, supplemented by studies of war diaries, intelligence reports, and recollections of officers and men, has helped clarify the story of the Korps and the battles which are recalled with accuracy and realism.—D. S. DUNCAN.

BOOKS RECEIVED

Engineering Approach to Gyroscopic Instruments. By Elliott J. Siff and Claude L. Emmerich. New York: Robert Speller & Sons, Publishers, Inc. 120 pp. $7.50.

Great Ideas of Modern Mathematics—Their Nature and Use. By Jagjit Singh. New York: Dover Publications, Inc. 311 pp. $1.55.

Guns of the Lewis and Clark Expedition. By Ruby E. Hult. Takoma: Washington State Historical Society. 20 pp. $1.

Hydrodynamics—A Study in Logic, Fact, and Similitude. By Garrett Birkhoff. Princeton: Princeton University Press. 184 pp. $6.50.

International Rectifier Solar Cell and Photocell Handbook. By John Sasuga. El Segundo, Calif.: International Rectifier Corporation. 111 pp. $2.

Introduction to Nuclear Science. By Alvin Glassner. New York: D. Van Nostrand Company. 213 pp. $3.75.

Introduction to the Statistical Dynamics of Automatic Control Systems (translated from the Russian). By V. V. Solodovnikov. New York: Dover Publications, Inc. 307 pp. $2.25.

Introductory Treatise on the Lunar Theory. By Ernest W. Brown. New York: Dover Publications, Inc. 292 pp. $2.

Management Guide to Applied Industrial Psychology. By Bernard T. Lewis and William W. Pearson. New York: John F. Rider Publisher, Inc. 80 pp. $1.50.

Manual of Spherical and Practical Astronomy, Vols. I & II. By William Chauvenet. New York: Dover Publications, Inc. 708 and 647 pp. $2.75 each.

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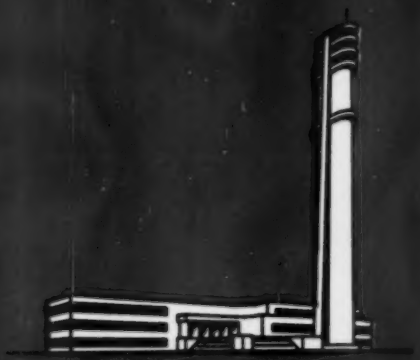

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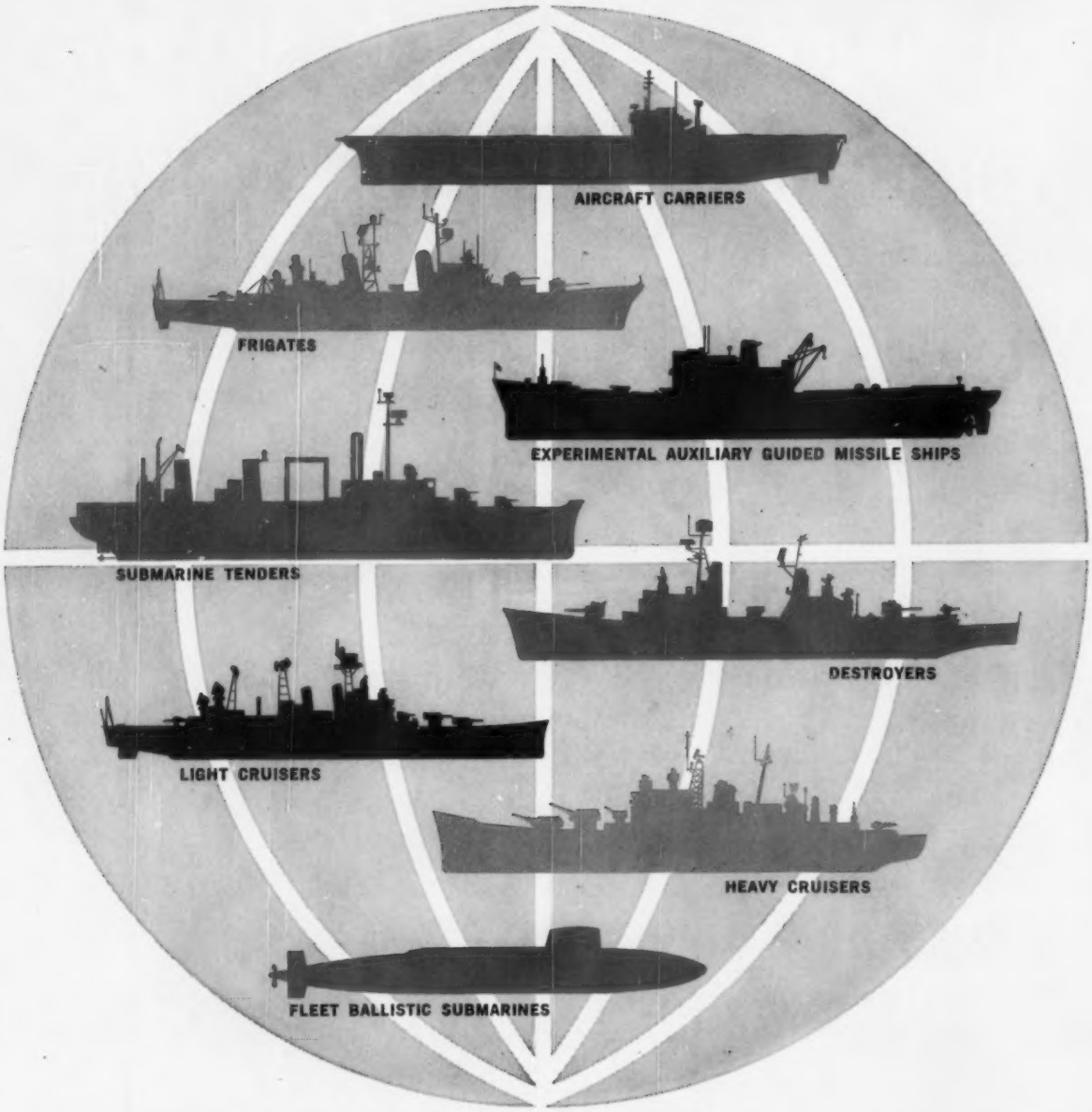

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Armament Technology

This section of ORDNANCE contains selected papers on armament technology presented at meetings of Technical Divisions and Sections of the American Ordnance Association and contemporary articles on armament research, development, manufacture, and field use

Combat Vehicle Stability

A study of the engineering mechanics of simulated firing effects

Mrs. F. Fischer

Senior mathematician, Dynamic Simulations Laboratory, Research Division, Ordnance Tank-Automotive Command, Detroit, Mich.

THE conduct of Ordnance vehicle research creates many varied problems requiring rapid and detailed analysis through the use and application of mathematical models and simulation techniques. One such area of investigation receiving major emphasis at the Ordnance Tank-Automotive Command is the study of combat-vehicle response during the firing cycle of main armament weapons.

This research was initiated to advance technology and to provide support for new military characteristics and design requirements where increased emphasis is being placed on the need for mounting larger-caliber weapons upon chassis of reduced weight and decreased size but with incresed mobility.

In keeping with this trend it has become necessary to establish, with greater accuracy, the firing stability of contemplated designs prior to extensive prototype development.

THE military vehicle, being a complicated dynamic system, will move in several different modes of motion simultaneously when disturbed by the trunnion reaction of a fired weapon. It is essential to understand the nature of these modes to evaluate their importance in relation to stability. At OTAC's Dynamic Simulations Laboratory these motion characteristics are derived and developed by application of Newton's laws for each degree of freedom.

Since it is necessary in many instances to simulate all degrees of freedom, the digital computer was deemed the most rapid and accurate means of accomplishing this task. The analysis herein, of a general system, establishes the equations to describe this engineering problem in a mathematical form sufficient for solution on an electronic digital computer with the objective of resolving stability in terms of displacements, velocity, and acceleration.

TWO Cartesian coordinate systems are used. One system is fixed and orients the vehicle in space. The second axis system is defined within the vehicle itself with the origin at the center of gravity, and this system moves with the vehicle. The motion of the vehicle is not given relative to the axes fixed in space to preclude necessary solution of varying moments and products of inertia for selected time increments.

To overcome this difficult and unwieldy problem the equations of motion are oriented relative to the moving vehicle axes. The fixed and moving axes coincide initially.

The vehicle, considered as a rigid body in space, is a 6-degree dynamic system. Its motion is defined by six components of velocity along and about the moving vehicle axis. It is assumed that the disturbed motion of the vehicle is one of small oscillations about a steady-state condition with a plane of symmetry coinciding with the x-z plane

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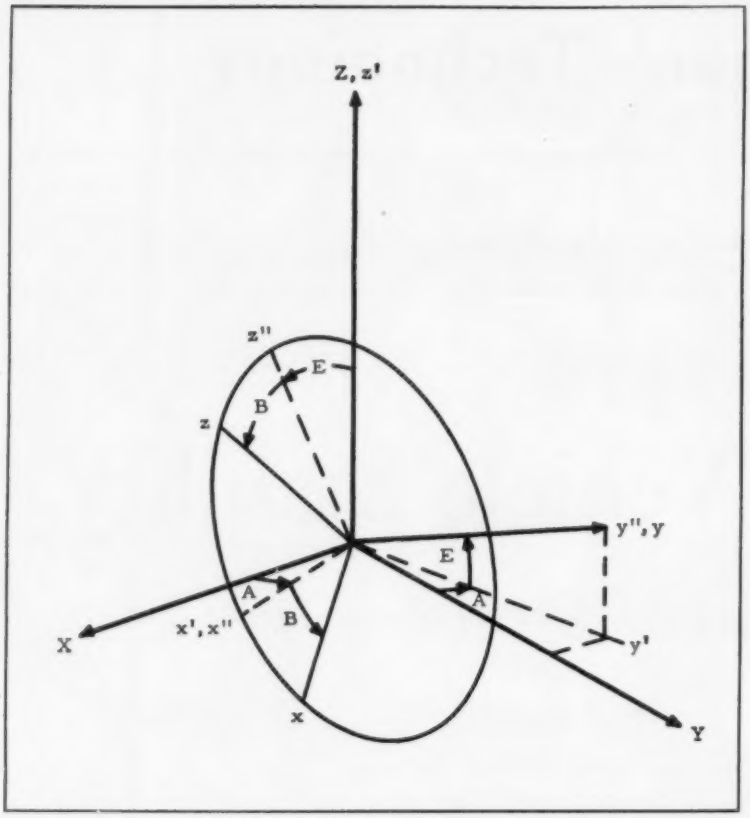


Fig. 1. Euler angles were used to orient vehicle axes with fixed-space axes.

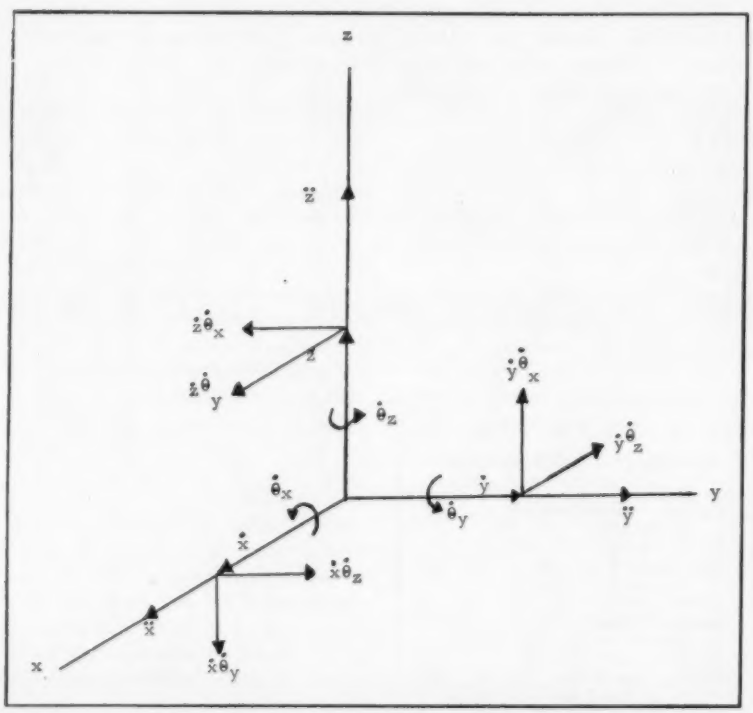


Fig. 2. Acceleration components referred to moving axes.

which eliminates two products of inertia, I_{xy}, and I_{yz}. Under these conditions, the general equations of motion are[1]:

Longitudinal translation:

$$\sum F_x = m(\ddot{x} - \dot{y}\dot{\theta}_z + \dot{z}\dot{\theta}_y) \qquad (1)$$

Lateral translation:

$$\sum F_y = m(\ddot{y} - \dot{z}\dot{\theta}_x + \dot{x}\dot{\theta}_z) \qquad (2)$$

Bounce:

$$\sum F_z = m(\ddot{z} - \dot{x}\dot{\theta}_y + \dot{y}\dot{\theta}_x) \qquad (3)$$

Roll:

$$\sum M_x = \ddot{\theta}_x I_x - \ddot{\theta}_z I_{xz} + (I_z - I_y)\dot{\theta}_y\dot{\theta}_z - I_{xz}\dot{\theta}_x\dot{\theta}_y \qquad (4)$$

Pitch:

$$\sum M_y = \ddot{\theta}_y I_y + \dot{\theta}_x\dot{\theta}_z(I_x - I_z) + (\dot{\theta}_x^2 - \dot{\theta}_z^2) I_{xz} \qquad (5)$$

Yaw:

$$\sum M_z = \ddot{\theta}_z I_z - \ddot{\theta}_x I_{xz} + (I_y - I_x)\dot{\theta}_x\dot{\theta}_y + I_{xz}\dot{\theta}_y\dot{\theta}_z \qquad (6)$$

THESE general equations are applicable to any vehicle system. The forces considered include the force of the gun, suspension system spring and damping forces, frictional forces produced by the track or wheels on the ground, sprung weight of the vehicle, and conditional forces caused by the road arm hitting the bump stop and the wheels leaving the ground. A schematic representation of a tank and the force system acting on it is shown in Figure 3.

Mathematically the gun force and suspension forces are represented as follows:

1. Gun force in x, y, z directions respectively:

$$F_{gx} = -F_g \cos a \cos e \qquad (7)$$

$$F_{gy} = -F_g \sin a \cos e \qquad (8)$$

$$F_{gz} = -F_g \sin e \qquad (9)$$

where a, e are the azimuth and elevation of the gun.

2. Suspension force at wheel i:

$$N_i = -K_i(z - x_i\theta_y + y_i\theta_x) - D_i(\dot{z} - x_i\dot{\theta}_y + y_i\dot{\theta}_x) \qquad (10)$$

1. "Airplane Performance Stability and Control," Perkins and Hage, 1949. John Wiley & Sons, Inc., p. 380.

where x_i, y_i give the position of wheel i,

K_i is the spring value,
D_i is the damping value.

The terrain dynamic frictional forces considered are those caused by the track of a tracked vehicle. The point of contact of the track on the ground is the location of the road wheels. The frictional force at each wheel is derived in vector form and applied at each wheel. Since the frictional force vector at wheel i is opposite in direction to the resultant velocity vector at wheel i, this direction, α_i, must be computed as follows:

$$\alpha_i = \arctan \left(\frac{\dot{Y} + \dot{\theta}_x \sqrt{x_i^2 + y_i^2} \cos(\beta_i + \theta_z)}{\dot{X} - \dot{\theta}_z \sqrt{x_i^2 + y_i^2} \sin(\beta_i + \theta_z)} \right) \quad (11)$$

where the subscript i denotes the wheel i;

$\dot{X}$, $\dot{Y}$ are the ground-velocity components along the fixed X, Y axes respectively; θ_z, $\dot{\theta}_z$ are the yaw angle and velocity; and $\beta_i = \arctan (y_i/x_i)$ with x_i, y_i designating the location of wheel i, with respect to the center of gravity.

With direction, α_i, known, the frictional force components at wheel i, F_{fix} and F_{fiy} are derived in vector component form as follows:

$$F_{fix} = -\mu(w_i + N_i c_{zZ}) \cos \alpha_i \quad (12)$$

$$F_{fiy} = -\mu(w_i + N_i c_{zZ}) \sin \alpha_i \quad (13)$$

where w_i is the unsprung weight at wheel i,

μ is the soil parameter, and c_{zZ} is the direction cosine of the z-vehicle axis and the Z-earth axis.

The total frictional force components for the complete vehicle are:

$$F_{fx} = \sum_{i=1}^{n} F_{fix} \quad (14)$$

$$F_{fy} = \sum_{i=1}^{n} F_{fiy} \quad (15)$$

IN the case of a zero resultant velocity vector, the static frictional force is dependent on the gun force. In the event the horizontal gun force is less than the product of the friction parameter and the total vehicle weight, then the static friction is equal to the gun force, but opposite in direction.

However, should the horizontal gun force be greater than the coefficient of friction multiplied by the total weight, then the x and y components of frictional force are:

$$F_{fx} = \mu W_T \cos a \quad (16)$$

$$F_{fy} = \mu W_T \sin a \quad (17)$$

where W_T is the total vehicle weight, and a is the azimuth of the gun.

The consideration of frictional forces automatically includes the use of soil parameters which permits the soil to be treated as an input variable. It is assumed that sinkage of the wheel or track is less than two inches, and that the bulldozing resistance is not appreciable.

Two conditions may be responsible for a wheel leaving the ground: the suspension forces may be sufficiently large to support the wheel from the ground, or occasionally a vehicle will have a rebound stop which limits the road-wheel travel. When either of these conditions exist, the wheel exerts an additional gravitational force and moment on the vehicle; thus the frictional and suspension forces for this wheel are zero.

Considering these forces, the specific equations of motion relative to the moving vehicle axes are:

Longitudinal translation:

$$F_{gx} + F_{fx} = m(\ddot{x} - \dot{y}\dot{\theta}_z + \dot{z}\dot{\theta}_y) \quad (18)$$

Lateral translation:

$$F_{gy} + F_{fy} = m(\ddot{y} - \dot{z}\dot{\theta}_x + \dot{x}\dot{\theta}_z) \quad (19)$$

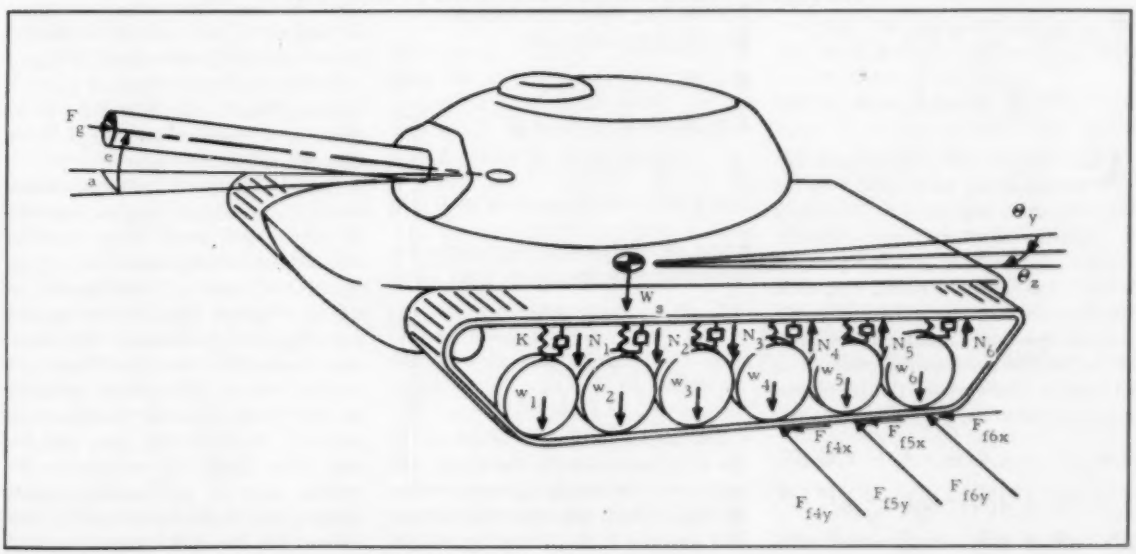
Bounce:

$$F_{gz} - W_T c_{zZ} + \sum_{i=1}^{n} N_i = m(\ddot{z} - \dot{x}\dot{\theta}_y + \dot{y}\dot{\theta}_x) \quad (20)$$

Roll:

$$-\bar{z}F_{gy} + \bar{y}F_{gz} + (z + z_0)F_{fy}c_{yY} + \sum_{i=1}^{n} N_i y_i = \ddot{\theta}_x I_x - \ddot{\theta}_z I_{xz} + (I_z - I_y)\dot{\theta}_y\dot{\theta}_z - I_{xz}\dot{\theta}_x\dot{\theta}_y \quad (21)$$

Fig. 3. Schematic representation of tank and force system acting on it.



Pitch:

$$-\bar{x}F_{gz} + \bar{z}F_{gx} - (z + z_0)F_{fx}c_{xX} - \sum_{i=1}^{n} N_i x_i = \ddot{\theta}_y I_y + \dot{\theta}_x\dot{\theta}_z \cdot (I_x - I_z) + (\dot{\theta}_x^2 - \dot{\theta}_z^2) I_{xz} \quad (22)$$

Yaw:

$$-\bar{y}F_{gx} + \bar{x}F_{gy} + \sum_{i=1}^{n} x_i F_{fiy}c_{yY} - \sum_{i=1}^{n} y_i F_{fix}c_{xX} = \ddot{\theta}_z I_z - \ddot{\theta}_x I_{xz} + (I_y - I_x)\dot{\theta}_x\dot{\theta}_y + I_{xz}\dot{\theta}_y\dot{\theta}_z \quad (23)$$

where: n = number of wheels, W_s = sprung weight; m = sprung mass, $\bar{x}$, $\bar{y}$, $\bar{z}$ = position of trunnion center line, z_o = static height of the center of gravity, and c_{xX}, c_{yY}, c_{zZ} = direction cosines between vehicle axes and earth axes.

TO set the initial conditions for the solution of the above equations, the following static equations for z, θ_x, and θ_y are solved:

$$-\sum_{i=1}^{n} K_i z + \sum_{i=1}^{n} K_i x_i\theta_y - \sum_{i=1}^{n} K_i y_i\theta_x = W_s \quad (24)$$

$$-\sum_{i=1}^{n} K_i y_i z + \sum_{i=1}^{n} K_i x_i y_i\theta_y - \sum_{i=1}^{n} K_i y_i^2\theta_x = 0 \quad (25)$$

$$\sum_{i=1}^{n} K_i x_i z - \sum_{i=1}^{n} K_i x_i^2\theta_y + \sum_{i=1}^{n} K_i x_i y_i\theta_x = 0 \quad (26)$$

ALL angular and translational disturbances are with respect to the vehicle's center of gravity. In the event it is necessary to study other vehicular locations such as the gunner's position, driver's seat, engine mounts, etc., these disturbances must be translated to the point in question. Considering the effect of the tangential and normal components of angular acceleration, the translation accelerations at the point j are:

$$\ddot{x} + z_j\ddot{\theta}_y - y_j\ddot{\theta}_z - x_j\dot{\theta}_y^2 - x_j\dot{\theta}_z^2 \quad (27)$$

$$\ddot{y} - z_j\ddot{\theta}_x + x_j\ddot{\theta}_z - y_j\dot{\theta}_x^2 - y_j\dot{\theta}_z^2 \quad (28)$$

$$\ddot{z} - x_j\ddot{\theta}_y + y_j\ddot{\theta}_x - z_j\dot{\theta}_y^2 - z_y\dot{\theta}_x^2 \quad (29)$$

in the x, y, z directions respectively, where x_j, y_j, z_j are the coordinates of the point j with reference to the center of gravity of the vehicle.

Translation velocities of the point j are:

$$\dot{x} + z_j\dot{\theta}_y - y_j\dot{\theta}_z \quad (30)$$

$$\dot{y} - z_j\dot{\theta}_x + x_j\dot{\theta}_z \quad (31)$$

$$\dot{z} - x_j\dot{\theta}_y + y_j\dot{\theta}_x \quad (32)$$

in the x, y, and z directions. The angular accelerations and velocities at point j are identical to those at the center of gravity.

Up to this point, all disturbances and their corresponding velocities and accelerations have been considered to be along and about the moving vehicle axes. With the vehicle axes moving with linear velocities $\dot{x}$, $\dot{y}$, and $\dot{z}$ and rotating with the angular velocities $\dot{\theta}_x$, $\dot{\theta}_y$, and $\dot{\theta}_z$, the linear accelerations relative to fixed space $\ddot{x}$, $\ddot{y}$, and $\ddot{z}$ can be developed from Figure 2 as follows:

$$\ddot{X} = \ddot{x} - \dot{y}\dot{\theta}_z + \dot{z}\dot{\theta}_y \quad (33)$$

$$\ddot{Y} = \ddot{y} - \dot{z}\dot{\theta}_x + \dot{x}\dot{\theta}_z \quad (34)$$

$$\ddot{Z} = \ddot{z} - \dot{x}\dot{\theta}_y + \dot{y}\dot{\theta}_x \quad (35)$$

To orient the vehicle axes x, y, z with respect to fixed space axes X, Y, Z, a method of angular measurement was used which utilizes a set of angles related to Eulerian angles (see Figure 1). First, the system is rotated through an angle A about the Z axis, then through an angle E about the x' axis, and finally through an angle B about the y'' axis. The resulting axis system coincides with the vehicle axis angles by:

$$\dot{B} = \dot{\theta}_y \quad (36)$$

$$\dot{E} = \dot{\theta}_x \cos B + \dot{\theta}_z \sin B \quad (37)$$

$$\dot{A} = -\dot{\theta}_x \sin B \cos E + \dot{\theta}_y \sin E + \dot{\theta}_z \cos B \cos E \quad (38)$$

where the dot designation denotes the derivative with respect to time. Thus,

$$B = \int \dot{B}dt \quad (39)$$

$$E = \int \dot{E}dt \quad (40)$$

$$A = \int \dot{A}dt \quad (41)$$

The angles B, E, and A do not in the strict sense describe the pitch, roll, and yaw of the vehicle but rather orient the vehicle with reference to fixed axes. The rotations B, E, A, must be made in sequence as defined above to give the exact attitude of the vehicle at time t.

From these orientation angles B, E, and A, it is necessary to find the direction cosines c_{xX}, c_{yY}, and c_{zZ} which are required to calculate the frictional forces and moments acting on the vehicle. These direction cosines c_{xX}, c_{yY}, and c_{zZ} give the inclinations of the x vehicle axis with the X fixed axis, the y vehicle axis with the Y fixed axis, and the z vehicle axis with the Z fixed axis. The relationship of these direction cosines to the angle B, E, and A are as follows:

$$c_{xX} = \cos A \cos B - \sin B \sin A \sin E \quad (42)$$

$$c_{yY} = \cos A \cos E \quad (43)$$

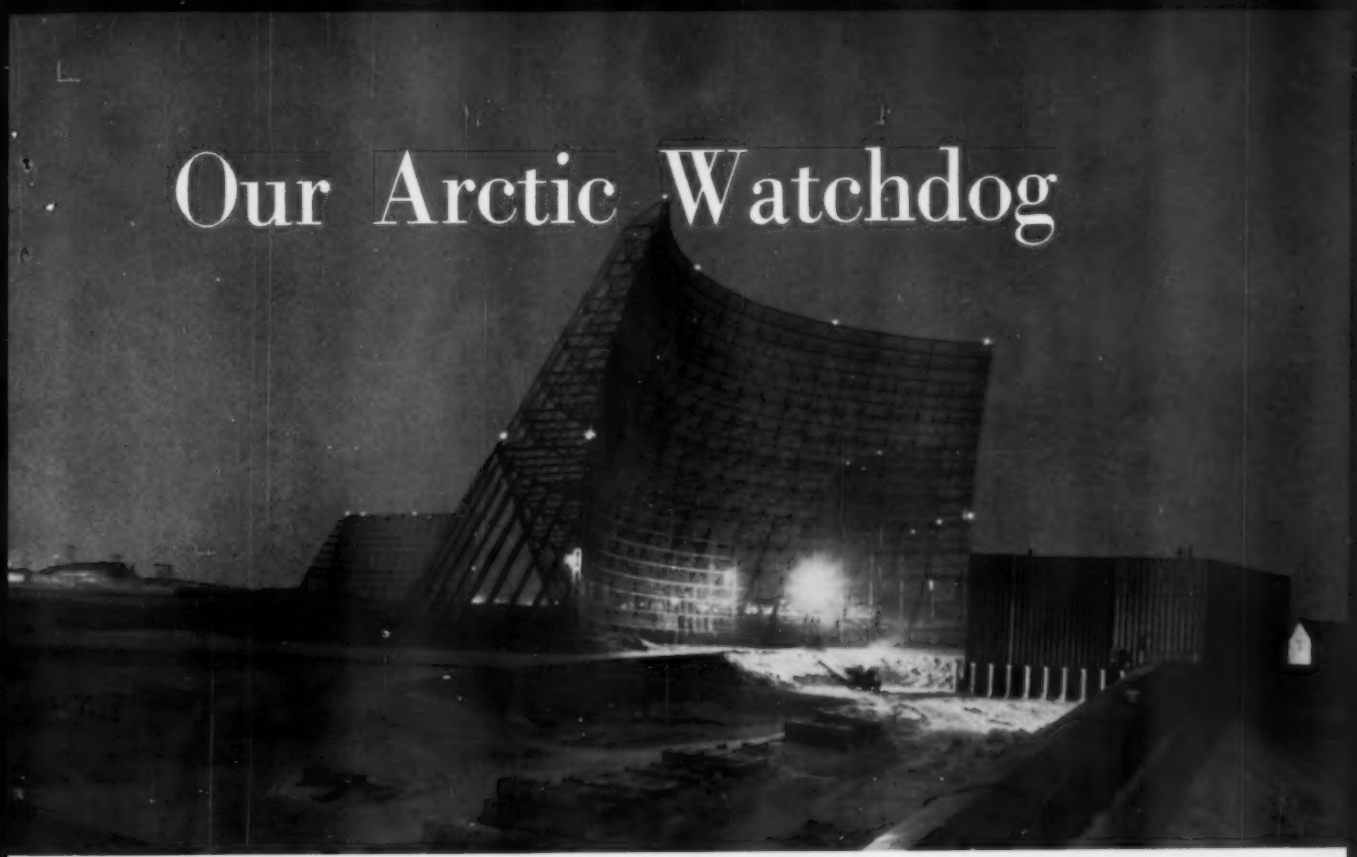
$$z_{zZ} = \cos B \cos E \quad (44)$$

AT this point, the problem is resolved to the numerical solution of six second-order differential equations describing the six degrees of motion along and about the vehicle axes, and the three second-order and three first-order differential equations describing the orientation of the vehicle axes with respect to the fixed earth axes. These differential equations are solved simultaneously with the aid of a fourth-order Runge-Kutta-Gill method subroutine.

The equations of motion presented in the mathematical model are for vehicle-mounted weapon systems that are free to move in three degrees of angular freedom and three degrees of translational freedom. These equations define the motion of the vehicle as affected by the combined interrelated factors of gun firing force, the force of gravity, terrain influence, and the resisting forces of the vehicle suspension springs, shock absorber, and bump stops.

The problem inputs consist of various vehicle measurements, weights, moments of inertia, gun recoil force, type of soil, and type of suspension. The output consists of detailed information in tabular or graph form showing angular and translation disturbances. This information describing the impact force and resultant vehicle vibrations is available for the center of gravity position with reference to earth-fixed axes and for any other point on or within the vehicle, such as gun muzzle, engine mounts, and commander's cupola with reference to the vehicle axes.

Our Arctic Watchdog



The huge radar antennas of BMEWS stand constant guard in Greenland

Robert S. Sartoris

ALTHOUGH accounts of 1960 in future history books will list a great many other important facts and scientific break-throughs, one of the most significant achievements appearing on the 1960 ledger will be the caging, if not the taming, of the dreaded ICBM. Not only did the year see the first ICBM's become operational, it also witnessed the occasion when the first ICBM detection installation swung into action.

When a switch was pulled October 1st, sending test signals from the free world's first missile warning radar station, the initial giant step was taken toward providing the North American Air Defense Command (NORAD) with the capability of blocking ICBM attacks against the U. S. and southern Canada.

Emanating southward from the Ballistic Missile Early Warning System (BMEWS) site at Thule, Greenland, these test signals activated special displays at the NORAD Combat Operations Center in Colorado Springs, Colo., giving the Command's battle staff its first look at alert signals like those that would warn of an ICBM attack.

Mr. Sartoris is with the Goodyear Aircraft Corporation, Akron, Ohio.

It took more than two years to design BMEWS and build the Thule site. The station, representing $500 million of the billion dollar BMEWS program, currently consists of four General Electric AN/FPS-50 detection radars. Employing fixed antennas larger than a football field turned on its side, these detection radars provide two stationary fans over a wide sector at different elevation levels with high power beams scanning across them.

The second type radar, now under construction at the site, is RCA's tracking radar AN/FPS-49, which can both scan and track. With the bases already in at the time the site became operational, erection and testing of giant radar tracking antennas, supporting pedestals, and enclosing radomes by the Goodyear Aircraft Corporation (GAC) is now almost completed.

The tracking radar is flexible in that it can be assigned to scan over various sectors at different elevation angles. Upon detection of a target, a designated tracking radar locks on and tracks the target to determine whether or not it is an ICBM and, if so, to obtain accurate data on its trajectory and thus predict the point of impact as well as the launching point.

Returns from the radars are automatically fed into electronic computers that calculate in thousandths of a second the course and speed of incoming missiles. The information is then passed over a complex communications network to NORAD where it is displayed and relayed to the Strategic Air

Command (SAC). The time from detection to display is a matter of no more than ten seconds.

The BMEWS display will indicate to NORAD and SAC battle staffs the size of the raid and the course and speed of the missiles. An evaluation of the seriousness of the attack will be indicated on a numerical scale.

Thus, although the U. S. does not at present possess an operational anti-ICBM weapon to tame the deadly critters, the BMEWS system does put the Nation a giant step forward by providing advance notice of ICBM attack. The long-range, ultrahigh-speed warning system will give NORAD, SAC, and Civil Defense agencies the brief but vital time necessary to take defensive and retaliatory measures in the event of an enemy missile attack on the North American Continent.

BMEWS consists of radar bases at Thule, Site I; Clear, Alaska, Site II; and Fylingdales Moor in Yorkshire, England, Site III. These sites were selected for BMEWS because they are so situated as to provide complete detection coverage of intercontinental ballistic missiles approaching southern Canada, the United States, or the United Kingdom from beyond the polar regions. The system includes a comprehensive communication system to flash warning and predicted missile impact information to NORAD headquarters at Colorado Springs for evaluation and action from all sites.

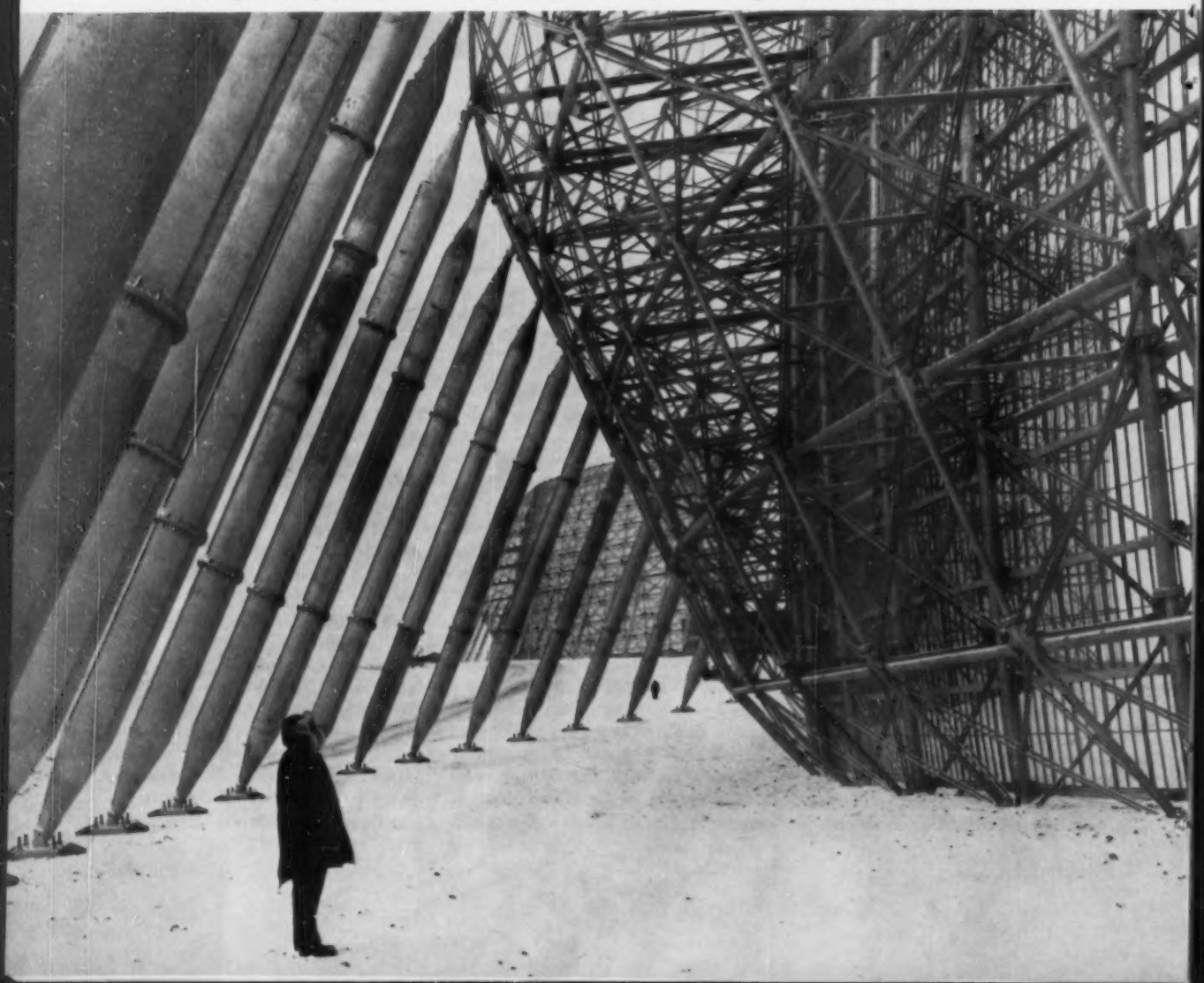
Each of the forward sites will eventually be a completely self-sufficient base, with giant radars, power supply, computers, and all necessary facilities to support administrative, operating, and maintenance personnel.

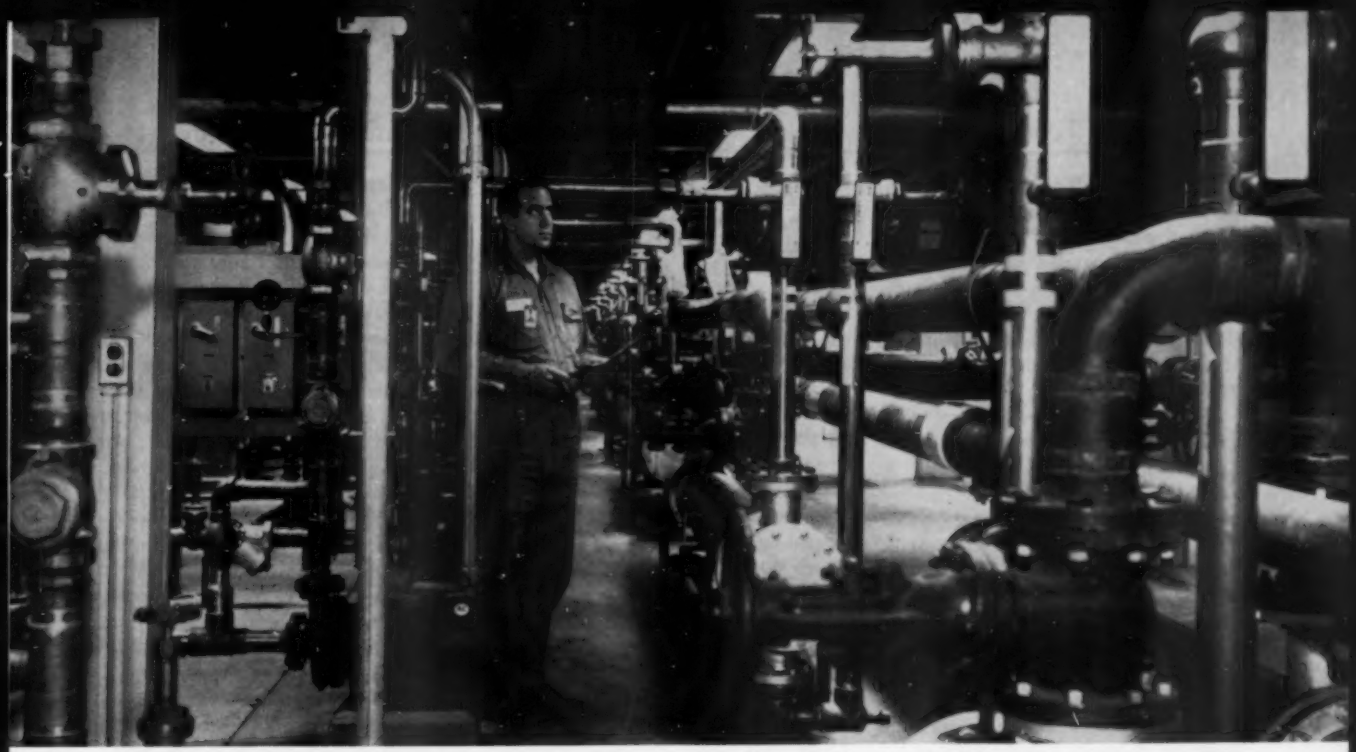
BMEWS is a tremendous cooperative project involving not only the Air Force but the Army, the Navy, and an industrial team of 2,900 large and small business suppliers located in 29 States from coast to coast.

The Air Force BMEWS Project Office at Laurence G. Hanscom Field in Bedford, Mass., directs the entire project. The office contains the Electronic Systems Center of the Air Matériel Command (AMC), the Air Research and Development Command (ARDC), with the AMC as executive agent. The Army's Corps of Engineers is supervising design and construction of the buildings at Thule and Clear. The Navy's Military Sea Transport Service provided the ships to deliver the vast tonnages of equipment, material, and supplies to Thule.

In January 1958, the Air Force

Made of special alloy to resist subzero temperatures and 185 m.p.h. winds, huge stanchions support Thule radar antenna.





Engineer checks inspection point on heat exchanger at BMEWS installation, Thule, Greenland.

awarded contracts for the design, installation, and operation of the system and complementary activities to a group of leading electronics manufacturers. Radio Corporation of America is prime system contractor to the Air Force for BMEWS. Western Electric Company has a separate prime contract for the communications network which will link the system with the North American Air Defense Command at Colorado Springs. RCA headquarters for the BMEWS project is the company's Missile and Surface Radar Division at Moorestown, N. J.

PRINCIPAL subcontractors to RCA include: General Electric Company, to furnish the detection radars; Goodyear Aircraft Corporation, to fabricate the tracking radar antennas, pedestals, and radomes; Sylvania Electric Products, Inc., to furnish a portion of the data-processing phases of the system. The RCA Service Company Division will install the field equipment and maintain and operate BMEWS for at least two years after completion.

The detection, identification, and tracking of enemy ballistic missiles aimed at southern Canada, the United States, and Great Britain will ultimately be accomplished by powerful detection and tracking radar transmitters with ranges up to 3,000 nautical miles.

The computing function at the forward sites is provided by a pair of solid-state computers. This duplexing of the computers permits one to take over the functions of another during either scheduled or unscheduled shutdowns, and thus assure continuous operation. The site computers accomplish the following functions.

1. Compute target trajectories from digitized target information.

2. Compare the trajectories with (1) observed satellites, (2) the characteristics of aurora, and (3) the characteristics of meteor trails to prevent erroneous identification.

3. Make crucial decisions in designating tracking radar to cover selected targets, should numerous targets appear.

4. Formulate messages giving target data and level of confidence for transmission to the Zone of the Interior display facility.

One of the most important contributions to the system's reliability is the automatic checkout and monitoring equipment. Vital points in the radar subsystem are monitored continuously to verify correct operation.

By means of punch cards and targets simulated on magnetic tape, any part of the system, or all of it, can be checked out automatically, thus permitting the reliability of the data to be accepted without question.

At the Zone of the Interior (Colorado Springs), data from the forward sites are decoded, evaluated, modified by other intelligence, and displayed. It is here that a display information processor (DIP) appraises the threat level and the degree of confidence in incoming information. The final decision is then made by the Zone of the Interior Command as to whether "this is an attack."

BMEWS Arctic bases will be thriving "small cities" complete with comfortable living quarters (two, or at most three, men to a room) good meals, medical facilities, and a variety of recreational outlets such as gymnasium, hobby shops, bowling alley, movies, TV, and sports in season.

The Thule site houses approximately 1,000 men. The climate is cold and dry with a temperature range of plus 60 to minus 40 degrees Fahrenheit. This site is isolated; MATS aircraft are the only means of transport for personnel.

THE Clear, Alaska, site will house approximately 600 men. The climate is cold and arid. The temperature can range from plus 95 to minus 60 degrees Fahrenheit. There is scheduled train service to and from the site; one each way daily, except in the winter when trains run two times a week. Roads are not yet available but are in the planning stage. Living and recreational facilities will be similar to those at Site I.

BMEWS sites will consist of high-power radars, plus support buildings. The active missile-detecting area of each site will be separated from the maintenance and emergency barracks area for operational efficiency and safety. Travel between buildings is through shielded passageways large enough to permit truck transit.

There are two types of local communications at the forward sites—operational and administrative. Included in these facilities are a telephone dial system, teletype system, paging or public address system, intercom system, radio system, digital data handling system, and a sound-powered system. Some of these systems are alarm-connected—a bell rings when the system fails for any reason. Even if there were a complete power loss, the sound-powered system would operate, since voice vibrations generate electricity for its operation.

"The detection, identification, and tracking of enemy ballistic missiles aimed at southern Canada, the United States, and Great Britian will ultimately be accomplished by powerful detection and tracking radar transmitters with ranges up to 3,000 nautical miles."

A FULL-SCALE model of the powerful tracking radar which Goodyear Aircraft has built is under test at RCA's Missile and Surface Radar Division at Moorestown, N. J. Another prototype of this radar is currently undergoing mechanical life testing at Goodyear Aircraft Corporation's huge 211-foot airdock in Akron. The huge assembly has been operating in an uninterrupted scan mode for nine months without failure or faltering. BMEWS tracking radars have been built to operate continuously for ten years without a major overhaul.

The giant GAC-built dome-shaped structure housing the tracking radar at Moorestown towers to the height of a 15-story office building. It consists of a 3-story base building, 145 feet square, topped by a specially treated paper-and-plastic sphere 140 feet in diameter. The dome is to protect the giant rotating "dish" antenna inside from frigid Arctic weather and winds reaching a velocity of up to 185 miles an hour.

The BMEWS radar range is 3,000 nautical miles—ten times that of the DEW Line radars. The increased range is achieved by the use of high-powered transmitters and giant reflectors which concentrate the transmitter energy into a narrower and more efficient beam. Other pertinent facts about the installation are:

Power Generation.—Site I alone requires a million watts of power—enough to light a city of 30,000 people. The power is supplied by a U. S. Navy generator ship.

Industrial Teamwork.—Both RCA and its major subcontractors themselves have hundreds of additional subcontractors. The Subcontracted Projects Activity within RCA directs the work of 485 large companies and 2,415 small companies contributing to the project—a total of 2,900. Sixty-six per cent of the total BMEWS contract is subcontracted, and about thirty-six per cent of the total dollars go to small business firms in twenty-nine States.

Number of People Engaged in Work.—An estimated 6,000 people in the U. S. are directly contributing their time and effort to the BMEWS project; uncounted additional thousands are producing various items of electronic and mechanical hardware.

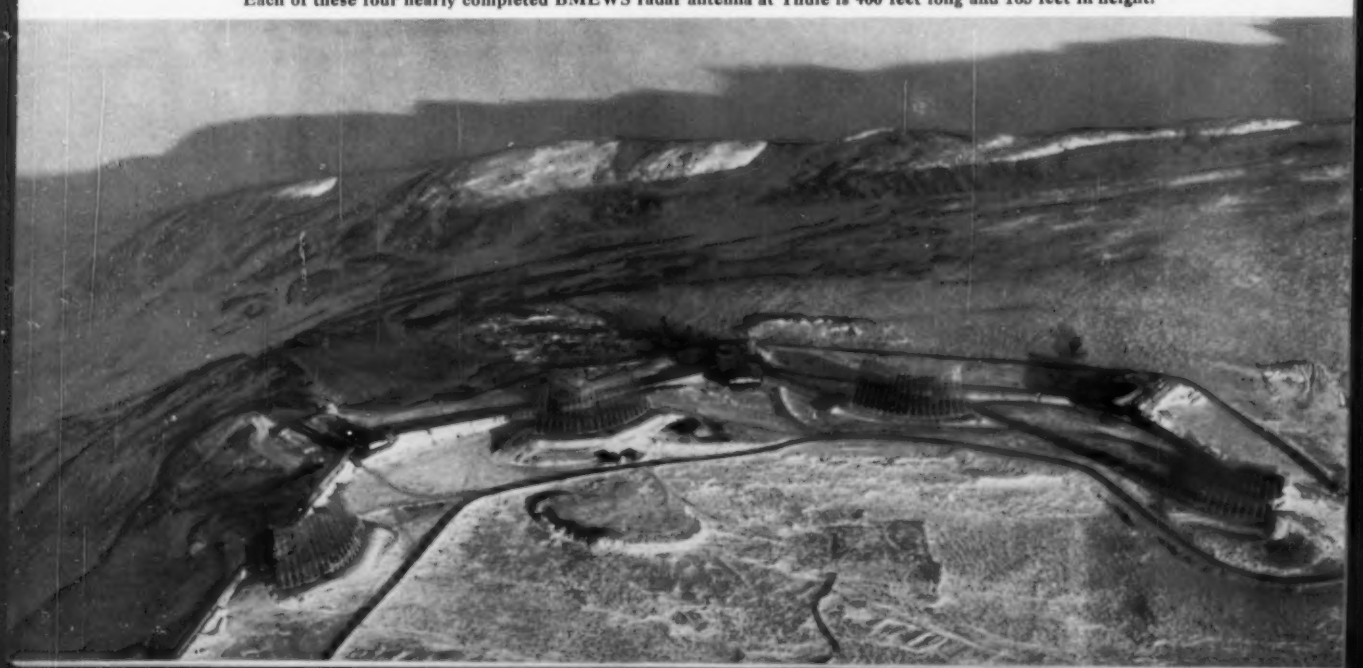
Personnel at Thule, Greenland.—More than 700 BMEWS engineers, technicians, administrative, and other personnel of RCA, its subcontractors, and the Air Force, are presently on location. The permanent force will approximate 1,000.

Tons of Equipment.—An estimated 150,082 measurement tons of all kinds of material were transported to Site I by sea, and 3,126 short tons by air since the project got under way early in 1958.

Magnitude of Equipment.—It is estimated that the operating equipment at BMEWS sites will exceed in bulk the combined equipment of all the broadcasting stations in the United States.

Schedules.—Construction of the Ballistic Missile Early Warning System Sites is on schedule. The first at Thule, Greenland, became operational October 1, 1960. The second, at Clear, Alaska, is expected to become operational sometime in 1961. Construction at the third site in Great Britain was begun a few months ago.

Each of these four nearly completed BMEWS radar antenna at Thule is 400 feet long and 165 feet in height.



Nuclear Power Plants

Continuing research and development on various types of reactors and fuel elements is resulting in an increase of experience and know-how that will lead to small and economical energy sources

Ulysses M. Staebler

THE objectives of the Civilian Nuclear Power Program of the United States basically call for development of technology which will permit the production of nuclear power at low cost. This will make it possible to provide economic benefits to wide areas—geographically and industrially.

It is estimated that in some situations even in the United States nuclear power may become competitive with power produced by fossil-fueled plants within the present decade, and, in fact, that some large plants that could be built now might prove to be economically competitive over their useful plant lifetime.

We have also recognized in the establishment of our program objectives and in the planning of our program that, in the long term, breeder-type reactors should be developed in order to make full use of the nuclear energy latent in both uranium and thorium.

THE average-size power plant being installed by utilities is increasing with time; however, there are very large numbers of consumers who still obtain their power from relatively small plants. The small-plant problem was given special attention in an invitation issued September 21, 1955, under the Atomic Energy Commission's Power Demonstration Reactor Program.

This invitation called for proposals to cooperate with the Commission in the design, construction, and operation of nuclear power plants in the range from 5,000 to 40,000 kwe. Two plants are now in advanced stages of construction as a result of the September 1955 invitation.

Mr. Staebler is senior assistant director, Division of Reactor Development, U. S. Atomic Energy Commission, Washington, D. C.

Our interest in small power reactors was given further specific recognition in 1959 when we initiated what may be described as a formal development program for small power reactors. This program includes an analysis of reactor concepts in terms of their applicability to plants in the range below 75,000 kwe. It represents an extension of previous work which considered plants in the range from 75,000 to 300,000 kwe. or more.

The direction of research and development work to date has not been influenced primarily by interest in a particular range of plant capacities. Rather, the work has been directed toward a better understanding of reactor technology so that improved assessments can be made of the applicability and economic promise of various segments of that technology.

Work to date has indicated that, in the United States, nuclear power is most likely to become economically competitive first in areas with relatively high fossil-fuel costs which can use large plants; that is, plants with a capacity of about 300,000 kwe. Thus our work may be considered somewhat oriented toward that expectation.

However, most of the work is equally applicable to much smaller plants. In fact, our work is carried out with emphasis on relatively small experimental reactors and prototype reactors for the larger plants. This results in operating experience which, in many cases, is perhaps even more directly applicable to the smaller-plant evaluation.

IN general, plants identified as prototypes for large plants are designed with the larger plant in mind rather than optimized for the capacity of the prototype. However, design modifications appropriate to optimize the plant for its particular capacity generally should be less difficult than those required to extrapolate to a plant of several times the prototype capacity.

The United States now has more than a dozen operable reactors designed and constructed specifically for developing information directly applicable to the production of electricity in nuclear plants. Nineteen others are under construction, and still more are planned.

Not included in these numbers are the units built for propulsion or for development of auxiliary power sources for spacecraft, the research and test reactors which are a vital part of the development program on materials, the critical facilities used to study the nuclear-physics characteristics of various cores, or the transient power test facili-

ties which have become so important to our study of reactor safety.

IT would be impractical in a single report to attempt to review significant features of each of these projects. Most of them have been described in some detail in previous literature. Some of special significance to the small and medium power field are mentioned briefly in the following paragraphs which are arranged according to reactor concept.

Pressurized Water Reactors.—Operation of the pressurized water reactor at Shippingport, Pa., continues to be the cornerstone of development for this concept. A second seed has been installed in the seed and blanket core and the reactor was returned to full-power operation in May 1960.

As of August 30, 1960, the blanket achieved an exposure of approximately 2,600 MWD/ton of UO_2 average or 12,400 MWD/ton maximum. This is the highest exposure achieved in large batches of uranium-oxide fuel.

Developments in support of this project have led to plans for core modifications after either the second or third seed which will result in a second core with an expected capacity of 150,000 kwe. equivalent gross (compared with 68,000 kwe. gross for the present design), without increasing the diameter of the pressure vessel.

PWR-2 will have about 5.5 times the PWR-1 design energy output per unit of fuel flow. This is to be achieved with compartmented flat plate uranium-oxide fuel clad in zirconium alloy.

The Yankee Atomic Electric plant achieved criticality in August 1960. Its operation will greatly accelerate the rate at which valuable operating experience on pressurized-water reactors is obtained. Some of its design features, such as stainless-steel-clad fuel, are sufficiently different from the Shippingport design to provide valuable comparative information for evaluation purposes.

The pressurized-water program also benefits from the operating experience gained by operation of the Army's Stationary Medium Power Plant No. 1 (SM-1) and from various other projects involving construction and operation of reactors for the Department of Defense.

Boiling Water Reactors.—Many possible design variations for boiling-water reactors are being explored or are to be explored in projects such as (a) the experimental boiling-water reactor, which is in final stages of modification to increase the heat dump capacity from 20,000 to 100,000 kilowatts thermal (kwt.); (b) the Vallecitos boiling-water reactor, which piloted design of the large 180,000 kwe. Dresden plant recently placed in operation; (c) the Rural Cooperative Power Association plant—a prototype 22,000 kwe. plant expected to be critical by 1961; (d) the 50,000 kwe. Big Rock Point plant of Consumers Power Company in Michigan which will explore increasing power density in the core from 35 kwt./liter to 60 kwt./liter as a means toward lower power costs, and (e) the 48,500 kwe. Humboldt Bay plant of Pacific Gas and Electric Company, which will exploit natural circulation and which will take advantage of a new containment philosophy, known as pressure suppression, in which vapor from a reactor incident would be expelled through a water pool and pressure reduced to a safe level by condensation.

Nuclear Superheat.—It is expected that the production of superheated steam in reactors will have some economic advantage in comparison with water-cooled reactors which now produce saturated steam. Several projects are directed primarily toward demonstration of technology which will make this possible.

These projects include, (a) the fifth Borax project of Argonne National Laboratory, a flexible experiment to be placed in operation in 1961; (b) the Pathfinder plant of Northern States Power Company, a 62,000 kwe. plant with a central superheat region, scheduled for completion in mid-1962; and (c) the Bonus (boiling reactor nuclear superheat) project of the Puerto Rico Water Resources Authority, a 16,300 kwe. plant with a peripheral superheat region, scheduled for completion in 1963.

Organic Cooled Reactors.—Operating experience with the Organic Moderated Reactor Experiment continues to be the principal source of data on organic material as reactor moderator and coolant. In order to broaden this experience and increase the rate of development of promising variants of this basic design, construction has been initiated on an experimental organic-cooled reactor to be completed in 1962. Construction also is proceeding on the 11,400 kwe. organic-moderated and -cooled reactor plant at Piqua, Ohio, scheduled for completion sometime during the current year.

The Commission invited proposals for a cooperative project to build a 50,000 kwe. organic-moderated and -cooled prototype power reactor, but no proposals were received. It is now considering further action in connection with this project.

Gas Cooled Reactors.—The program for development of gas-cooled reactors in the United States covers materials and designs appropriate to a wide range of exit coolant temperatures, from 1,000 degrees Fahrenheit to over 2,000 degrees. Reactor projects of this program, in operation or under construction, include the following:

a. The Experimental Gas Cooled Reactor, with a capacity of 22,300 kwe., under construction and scheduled for completion at Oak Ridge National Laboratory in 1962. It is designed to include special loop facilities for testing materials beyond its normal operating condition.

b. The Gas Cooled Reactor Experiment, a 2,000 kwt. plant which achieved full-power operation last July and which is a step in the development of a direct and closed-cycle gas-cooled mobile nuclear power plant.

In addition to these projects, development is proceeding and there is a firm commitment to build the High Temperature Gas Cooled Reactor, with a capacity of 40,000 kwe., with unclad fuel, on the system of the Philadelphia Electric Company.

Sodium Cooled Reactors.—Sodium-cooled reactors are of interest in a wide range of neutron energy spectra from thermal, through intermediate, to fast. Reactors exploiting the thermal neutron energy range include the Sodium Reactor Experiment which has been put back into operating condition following fuel failure last summer due to coolant channel plugging by carbonaceous material.

The new core for this reactor consists of thorium-uranium alloy and will provide information on the high-temperature nuclear and physical characteristics of this material. The 75,000 kwe. Hallam nuclear power facility includes design improvements based on experience with the SRE. Construction is proceeding, and it is expected to be completed in 1962.

The first experimental breeder reactor, a fast reactor, continues to operate at the National Reactor Testing Station. Having essentially completed studies of transient behavior of the core with varying degrees of fuel rigidity, the reactor core now includes sample plutonium-bearing fuel materials, and a full plutonium core is in preparation. Construction of the second experimental breeder reactor is nearing completion, and start-up of this 16,500 kwe. plant should take place early in 1961.

Construction of the 94,000 kwe. Enrico Fermi fast reactor also is nearing completion. Scheduled startup will depend upon resolution of licensing problems created by recent court decisions, but the plant will be ready for operation in 1961.

Heavy Water Moderated Reactors.—The United States is working closely with Canada in the development of heavy-water-moderated power reactors. In addition, construction of a 17,000 kwe. tube-type plant has been initiated by the Carolinas-Virginia Nuclear Power Associates. This plant is to be completed in 1962.

Also pertinent to the development of heavy-water-moderated power reactors is the fact that two such reactors, each of approximately 70,000 kwt. capacity, are well along in construction. One of these is tube type—the other is tank type. They are known as the Plutonium Recycle Test Reactor and the Heavy Water Components Test Reactor, respectively.

Other Work.—Research and development are continuing on a number of reactor concepts which appear to have certain advantages but which are not yet to a point where technical feasibility is assured or reasonable evaluations can be made. Many reactor concepts are being evaluated as candidates for new reactor experiments.

Studies also are being carried out on direct-conversion systems involving thermionic, thermoelectric, and magnetohydrodynamic devices. Hopefully, such devices may make it possible in the long run to take better advantage of the unique ability of nuclear fuels to produce high temperatures which may be employed in useful work.

In addition to the specific work that is carried on under individual power-reactor projects, the development program includes an area of more broadly based nuclear technology development which is generally applicable to nuclear systems including, for example, environmental investigations and development of practical systems for the safe handling and disposal of the wide variety of radioactive wastes evolved from nuclear-energy activities.

An intensive experimental and theoretical program is in progress on reactor safety. This program includes six reactors specifically designed for transient tests. Results of this work so far indicate that real progress has been made in understanding self-shutdown characteristics of reactors which leads to a certain amount of optimism that inherent self-protection characteristics can minimize the need for complicated and expensive containment and emergency control systems.

This work is of particular importance to small-sized reactors since the economics of small plants is severely penalized by extra fixed charges, such as introduced by containment shells and other protective auxiliary systems.

OUR plans for the future continue to emphasize technology and experience through laboratory experiments, theoretical analysis, and experi-

This Sodium Reactor Experiment near Los Angeles is part of a program to develop an economical nuclear power source.

mental operation of a variety of facilities.

Since our research and development program is to emphasize cost reduction, it is clear that its general direction in all cases will have the same specific technical objectives. For example, the program will seek:

1. High specific power in terms of heat generation per unit mass of fuel inventory and high power density in terms of heat generation per unit volume of the reactor.
2. High thermal efficiency—implying high coolant temperature.
3. Low-cost fuel cycle, requiring a high irradiation level for the fuel and low fabrication and reprocessing costs.
4. Favorable neutron economy.
5. Simplicity, reliability, and safety of plant design.

Obviously, these technical objectives, each of which individually is desirable, interact in a complex way so that an over-all system optimization must accept compromises. The nature of the compromises which result in the most favorable system will depend upon the nature of the application, the size of the plant, local geographical and economic ground rules, and the status of pertinent technology at the time of the optimization.

Of the many areas of technology which must be considered in assessing the status and potential of nuclear power and in planning development effort, perhaps the most important single item for attention is the fuel cycle. Fuel technology seems to permeate the design problem. Physical and nuclear characteristics of the fuel generally determine the choice of coolant, temperature of operation, geometry of fuel, specific power of the core, and frequency of reprocessing.

THUS it is natural that the largest fraction of our continuing research and development effort will be related directly or indirectly to the improvement of nuclear fuels and nuclear fuel processing cycles. In the water-cooled reactor systems, uranium dioxide has become favored because of its radiation stability and compatibility with water.

Continuing efforts will emphasize new and cheaper fabrication techniques; new shapes for higher power density; alternate cladding materials and techniques; long-life tests of the consequences of fission product build-up; and techniques for using burnable poisons to flatten power distribution, reduce control problems, and extend fuel reactivity lifetime.

Alloys of uranium and up to ten per cent molybdenum are now being used in organic- and sodium-cooled reactors but alternative fuels are being developed. In the case of organic-cooled systems, uranium-carbide or uranium-oxide fuel, clad in a power compact of aluminum and aluminum oxide, is of principal interest.

THE usual uranium-oxide fuel clad in zircalloy or stainless steel is not satisfactory in organic-cooled systems because of hydriding in the former and poor thermal conductivity of the latter. Fuels being developed for the sodium-cooled systems attempt to take full advantage of the excellent heat-transfer characteristics of sodium.

Tests indicate that uranium carbide has good radiation damage characteristics at elevated temperatures. It also has much improved thermal conductivity compared with the oxide; thus it is considered to be most promising for sodium-cooled systems at the present time. Work on a thorium-uranium alloy also is being carried on but on a much lower scale.

Sodium-cooled fast reactor fuels now being used include both the uranium-molybdenum alloy and a uranium-fission alloy containing a mixture of fission products at equilibrium levels expected with the present pyrometallurgical reprocessing scheme. Future cores are expected to use ceramic and cermet fuel and blanket materials involving plutonium and uranium carbides or oxides either separately or in metallic matrices such as niobium or stainless steel.

Gas-cooled reactors currently under construction or in advanced stages of planning will use fuels of uranium oxide clad in stainless steel, uranium oxide clad in finned beryllium, and uranium and thorium carbides dispersed in a graphic matrix with no cladding other than low-permeability graphite.

The development trend is toward high-temperature systems of the latter type. In this case one of the major problems is the design of systems to trap or control fission product contamination in the primary system for operability and maintenance.

These examples of fuel development problems and directions represent only some of the items in this limited though very important development area. The program includes numerous measurements of physical and nuclear properties of potential fuel materials, compatibility tests of these fuels with structural and coolant materials, and experiments to determine fabricability of solid systems or dynamic characteristics of fluid systems.

The work on nuclear fuel systems will be supplemented by work on nuclear physics in many different configurations, heat transfer with a variety of coolants, reactor components unique to needs of specific concepts, reactor safety, and other areas of technology. This work is expected to lead to initiation of construction of approximately 10 new prototype reactors in the range of 20,000 to 100,000 kwe. during the next 5 years in addition to several experiments to explore advanced concepts.

STUDIES now in progress will provide a basis for sharper focus of our development program in terms of the special needs of small and medium-size nuclear power plants.

It is perhaps significant to note that our first decision to build nuclear power plants on the basis of favorable economics involves the construction of small plants. The first of these, a pressurized-water reactor, designed for production of only 1,500 kwe., is to be located at McMurdo Sound in Antarctica and is scheduled for operation early in 1962. It is expected that other plants for Antarctica will follow this one.

The entire nuclear power development program of the United States is directed toward providing results which will make it possible to evaluate more realistically alternative nuclear and nonnuclear systems for a particular application and, once selected, to build more nearly optimum nuclear plants for that particular application.

"The United States now has more than a dozen operable reactors designed and constructed specifically for developing information directly applicable to the production of electricity in nuclear plants."

Plating Gun Bores

Recent experiments show that a thick inner plating of chromium can increase gun barrel life as much as fivefold which should help solve the problems caused by today's high cyclic rates of fire

Vernon A. Lamb and John P. Young

PRESENT-day military guns are fired at much higher muzzle velocities and rates of fire than they were, for example, at the time of World War I. As a result, the life of a steel barrel may be so short as to make the weapon in which it is used nearly impractical. It was therefore a matter of great importance to seek means for extending the life of gun barrels.

In 1921, De Sveshnikoff and Haring of the National Bureau of Standards performed some experiments on the deposition of nickel, copper, and iron in gun bores. They made no firing tests, but recommended that further studies be made, preferably with iron, nickel, cobalt, and chromium.

Between 1926 and 1928, some caliber .30 machine-gun barrels were chromium-plated and tested at Frankford Arsenal by Maj. J. McDonald and Willard Scott. This work was continued at Frankford Arsenal by Lieut. A. Willink. A few chromium-plated barrels also were tested at Aberdeen Proving Ground. None of these tests indicated that chromium plating resulted in outstanding improvement in barrel life.

IT is now known that the failures of these early tests were due to the use of coatings that were too thin. From 1928 to 1945, plating of the bores of naval guns of calibers from 1.1 to 16 inches with a 0.0005- to 0.001-inch thickness of chromium was standard production practice at the Washington Naval Gun Factory. These thin coatings did not greatly increase the life of the barrels but no doubt furnished protection against corrosion, especially in sea atmospheres. Additional early interest in chromium-plated gun barrels is shown by patents in this field (Fabrique Nationale D'Armes de Guerre, Belgian Patent No. 361,579, issued 1929).

Both Mr. Lamb and Mr. Young are with the National Bureau of Standards, Washington, D. C.

In 1943, a program on gun-bore plating was started at NBS, in cooperation with the Geophysical Laboratory, Franklin Institute, and Springfield Armory under sponsorship of Division 1 of the National Defense Research Committee. From 1945 to 1957, the program at NBS was continued under the sponsorship of the Department of the Army, Office of the Chief of Ordnance and Springfield Armory, and of the Navy Bureau of Ordnance.

The initial objectives were, first, to develop a chromium plate or other plated-metal coating with properties better adapted to the improvement of gun barrels than ordinary "hard" chromium, and, secondly, to improve the performance of the caliber .50 machine-gun barrel. The program was later extended to barrels of other calibers.

The search for a bore coating better than hard chromium was not successful. Materials with somewhat improved properties in specific barrels were found, but for general use in most types of barrels electroplated hard chromium remains the best material available. The work with caliber .50 barrels showed that thick deposits of hard chromium yield significant improvement in the life and performance of the barrels. Work performed at Springfield Armory and at Battelle Memorial Institute with 37-mm. cannon led to similar conclusions.

AS a result of these researches, the Ordnance Departments of both the Army and the Navy undertook procurement or production of several calibers of small arms and cannon barrels plated in the bore with thick deposits of chromium.

Tests carried out at the Geophysical Laboratory showed that, to resist erosion, the material of the bore surface should have a high melting point, high hot strength and hot hardness, and adequate ductility; it should undergo no abrupt change of volume with temperature, and should be resistant to chemical attack by hot powder gases. Unfortunately, no such ideal material exists.

The tests showed further that, of all of the elements, only the following and some of their alloys are resistant to chemical attack by powder gases: chromium, molybdenum, tungsten, tantalum, nickel, cobalt, copper, and certain platinum-group metals. The platinum

metals are too expensive and scarce to consider, and the melting points of nickel, cobalt, and copper are too low.

Of the four refractory metals in this list, only chromium can be electrodeposited by practicable procedures. Therefore, most of the barrels tested in this program were chromium-plated.

However, firing tests also were performed with barrels containing bore coatings of alloys of chromium with iron, nickel, and cobalt, alloys of cobalt with tungsten, and duplex coatings of chromium with copper, cobalt, and cobalt-tungsten alloy. None of these proved superior to chromium.

The processing steps required for plating gun barrels with chromium are similar to those for plating many ordinary items and are practicable production operations. Electropolishing is used to remove metal from the surface of the bore to make room for the plate.

THE variables that were investigated in attempting to obtain optimum performance of chromium-plated barrels included the following: adhesion of chromium to the basis steel; thickness; different thicknesses in different regions of the bore; dimensional variables, such as undersized bores and muzzle chokes; properties of the chromium deposits; heat treatment after plating; and modifications of the barrels, such as hardened basis steel and increased length of the run-up of the lands at the origin of rifling.

The effects of these variables on the performance of chromium-plated barrels are described in the following paragraphs.

Chromium plate that is weakly adherent to the basis steel will be removed quickly during firing due to the large forces exerted on it by the projectile. The apparent adhesion is affected, not only by the cleaning and preplating treatments applied to the basis steel but also by the strength of the chromium.

The latter factor is important, because a chromium plate with "good" adhesion, when removed from the basis metal due to a tensile or shear stress, usually fails within the plate immediately adjacent to the basis steel.

Extensive tests led to adoption of electropolishing, followed by anodic etching in a chromic acid solution, as a cleaning procedure. Electropolishing thus serves the triple purpose of removing a layer of steel, smoothing the surface, and cleaning it. This procedure consistently yielded good adhesion, as judged by firing performance.

Quantitative measurements by Williams and Hammond of the adhesion of chromium to steel showed that a cleaning procedure similar to the above yielded adhesion of about twelve tons per square inch for hard chromium. This is somewhat higher than the tensile strength reported for this type of chromium—seven to eight tons per square inch—and indicates that the adhesion obtained is at least equal to the strength of the chromium.

In general, the optimum thickness of chromium increases with the caliber of the barrel. If electrodeposited chromium were stronger than it is, it is probable that a thick deposit of five to fifteen mils would be best for all sizes of barrel. However, because of its low strength and ductility, it tends to break away from lands unless it is reenforced by an underlying steel land of sufficient height.

SINCE the height of the lands increases with caliber, the thickness of chromium that can be used also increases with caliber. A thickness of chromium equal to one-half to two-thirds of the land height is adequately reenforced by the underlying steel. Greater thicknesses result in nearly "solid chromium" lands which cannot withstand the shear force due to acceleration of the projectile and tend to break off early in the firing life of the barrel.

This limitation on thickness applies mainly in the region near the origin of rifling, where the plate is subjected to maximum stress and erosive conditions. A thicker plate can be used in the muzzle region. The thicker plate in this location is not necessary for erosion protection, but may be desirable in some cases as a means of producing a choke.

Thus, in caliber .30 and caliber .50 barrels, a tapered plate is applied which is two to three times thicker at the muzzle than at the breech. The resulting choke produces a marked increase in accuracy life. Plates thinner than the optimum discussed above are sufficient at points in the bore some distance beyond the origin of rifling; *e.g.*, ahead of a breech liner.

Chromium has excellent chemical resistance to powder gases, and its melting point of approximately 1,900 degrees centigrade is amply high. We have never observed evidence of melting of chromium plate in a gun bore. The properties of three "types" of electrodeposited chromium are summarized in Table I. In this table, standard, hard chromium is designated "HC" (for

Table 1. Correlation between operating conditions of plating bath and properties of plates for three types of electrodeposited chromium.

Solution composition: 250 g. CrO_3/liter, 2.5 g. H_2SO_4/liter

Type	*Standard hard chromium (HC)*	*Medium hardness chromium (MH)*	*Soft or low contraction chromium (LC)*
Operating temp. (° C)	50	75	85
Current density (amp./dm.²)	20	60	80
Hardness (Knoop)			
at room temp.	920	685	550
at 600°C	167	—	111
at 800°C	70	—	48
Ductility	0	0	0
Tensile strength (lb./in.²)	15,000	—	70,000
Oxide content (wt., % of O_2)	0.40	0.12	0.05
Linear contraction after heating (%)			
to 450°C	0.3	—	—
to 1,200°C	0.8	0.1	0.1

"high contraction") because of the relatively large contraction that occurs when it is successively heated and cooled. Its hardness is adequate, since swaging of the plate itself is rarely a cause of gun-barrel failure.

Its main defects for gun-barrel service are that it is brittle and the contraction referred to above causes widening of the stress cracks inherently present. These adverse properties cause eventual failure of the plate in a gun barrel by the following mechanisms:

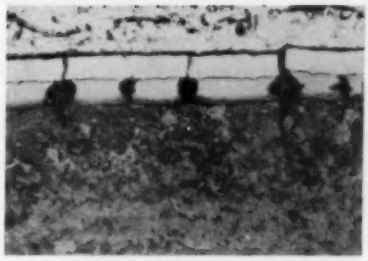
First, owing to its brittleness and low tensile strength, the plate may chip off by breaking within itself, especially at such highly stressed locations as land edges. The local thinning of the plate by this mechanism results in reduced protection to the underlying steel in these areas.

Secondly, hot powder gases gain access to the underlying steel through the cracks in the plate. The steel undergoes chemical attack and is melted by the hot gases. The result is the formation of mushroomed cavities under the plate at crack sites. Joining of two adjacent cavities by lateral growth results in removal of chromium from the bore; erosion of the exposed steel then proceeds at an accelerated rate. (See top photo above.)

The second mechanism of failure described above is partly the result of the poor chemical resistance and low melting point of steel. Another mechanism of failure is related to the low hot hardness of steel. Under impact from the projectiles, the steel of the lands under the plate flows both forward and laterally. Forward flow may produce a constriction in the bore; lateral flow increases the land diameter and decreases the groove diameter. (See bottom photo above.)

THIS distortion of the original surface contour results in buckling and cracking of the plate, which opens the way to erosion of the basis steel. In spite of the above types of failure, properly applied HC chromium produces a significant improvement in barrel life.

The plate referred to in Table I as "LC," or "low-contraction," chromium is markedly stronger than the HC type, is nearly crack-free as plated, and contracts much less than the latter as a result of cyclic heating and cooling. It



Mushroomed cavities in steel under cracks in the chromium plate.

Lateral flow of steel in the land, result of forces exerted by projectile.

was tested extensively in gun barrels and was found to yield slightly longer barrel life than HC chromium in some types and calibers of barrels, but, in most, it is no better than the HC type.

Its chief defect is its low hardness at medium-high temperatures (400 to 500 degrees centigrade), which permits flattening of the lands due to swaging. This deformation results in loss of accuracy.

Chromium plate of the "MH" (medium-hardness) type was tried in the hope that the favorable properties of both HC and LC plates would be combined in it. Unfortunately, the performance of the MH plate was characteristic of the unfavorable properties of both other types. Considering all factors, HC chromium was the most satisfactory type of plate in most barrels.

Barrels for submarine service, which are exposed to corrosion by sea water, were an exception. In these barrels, LC chromium was markedly superior.

Machine parts are commonly heat-treated, after hard-chromium plating, to relieve hydrogen embrittlement and to increase fatigue strength.

Sixteen barrels of several calibers were therefore heated after plating to temperatures between 200 and 600 degrees centigrade, at various rates of heating. Subsequent firing tests demonstrated that in no case did the heat treatment result in improved performance.

In the initial work with chromium-plated caliber .50 machine-gun barrels it was found that failure occurred because of velocity drop due to enlargement (at the origin of rifling) caused by swaging of the underlying steel. It appeared, therefore, that hardening of the steel at the surface of the bore might result in greater improvement.

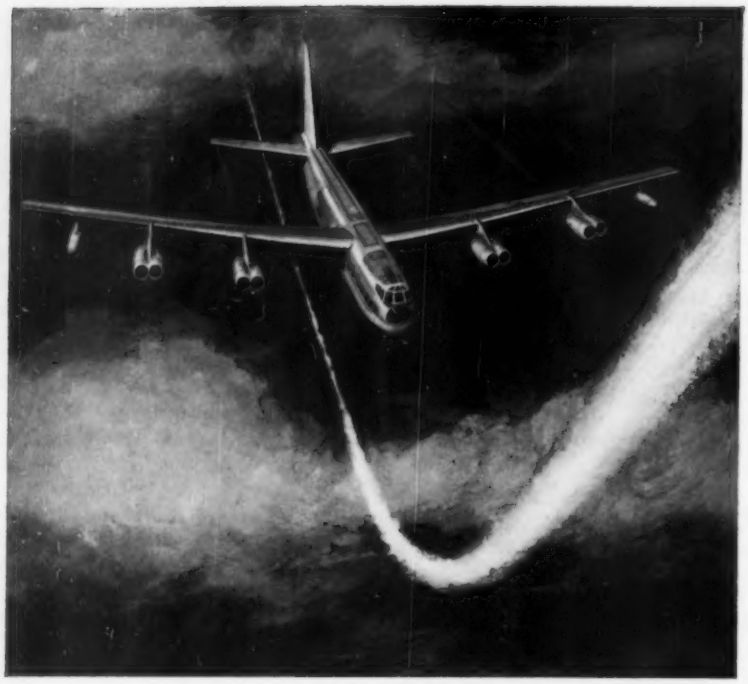
Case-hardening of the bore by carburizing and by nitriding were tried. Carburizing was ineffective, but nitriding resulted in a further improvement of 20 to 30 per cent, and was adopted for production (U. S. Patent No. 2,799,959, issued 1957). Nitriding increases the firing life of chromium-plated caliber .30 barrels about 15 per cent and of 20-mm. barrels about 10 per cent.

A choke was effective in all types of barrels in which it was tested, up to and including 40-mm. barrels. In addition to yielding increased accuracy life, a choke results in a decreased size of target-pattern of about 20 per cent.

IT was thought that, if the run-up of the lands (*i.e.*, the distance from the forward end of the bullet seat to the point at which the lands reach full height) were longer, and hence the engraving of the projectile were to occur over a greater length of bore, the forces on the plate and basis steel would be reduced.

Most of the tests of long run-ups employed 20-mm. barrels in which a length of run-up of ten inches was optimum. When used in combination with thick (0.012-inch) HC chromium, improved barrel-life was obtained. Without the long run-up, this thickness of HC chromium fails relatively early, due to cracking and removal of plate. In combination with LC chromium, which fails because swaging enlarges the bore, the long run-up was not effective.

Extensive firing tests of chromium-plated barrels, ranging from caliber .22 rifles to 3-inch cannon, have shown that thick chromium plate yields two- to fivefold increases in barrel life. The degree of improvement is most pronounced when barrels are fired under severe conditions; namely, on rapid-fire schedules, with high, muzzle velocity, high rate of fire, and with powder of high flame temperature.



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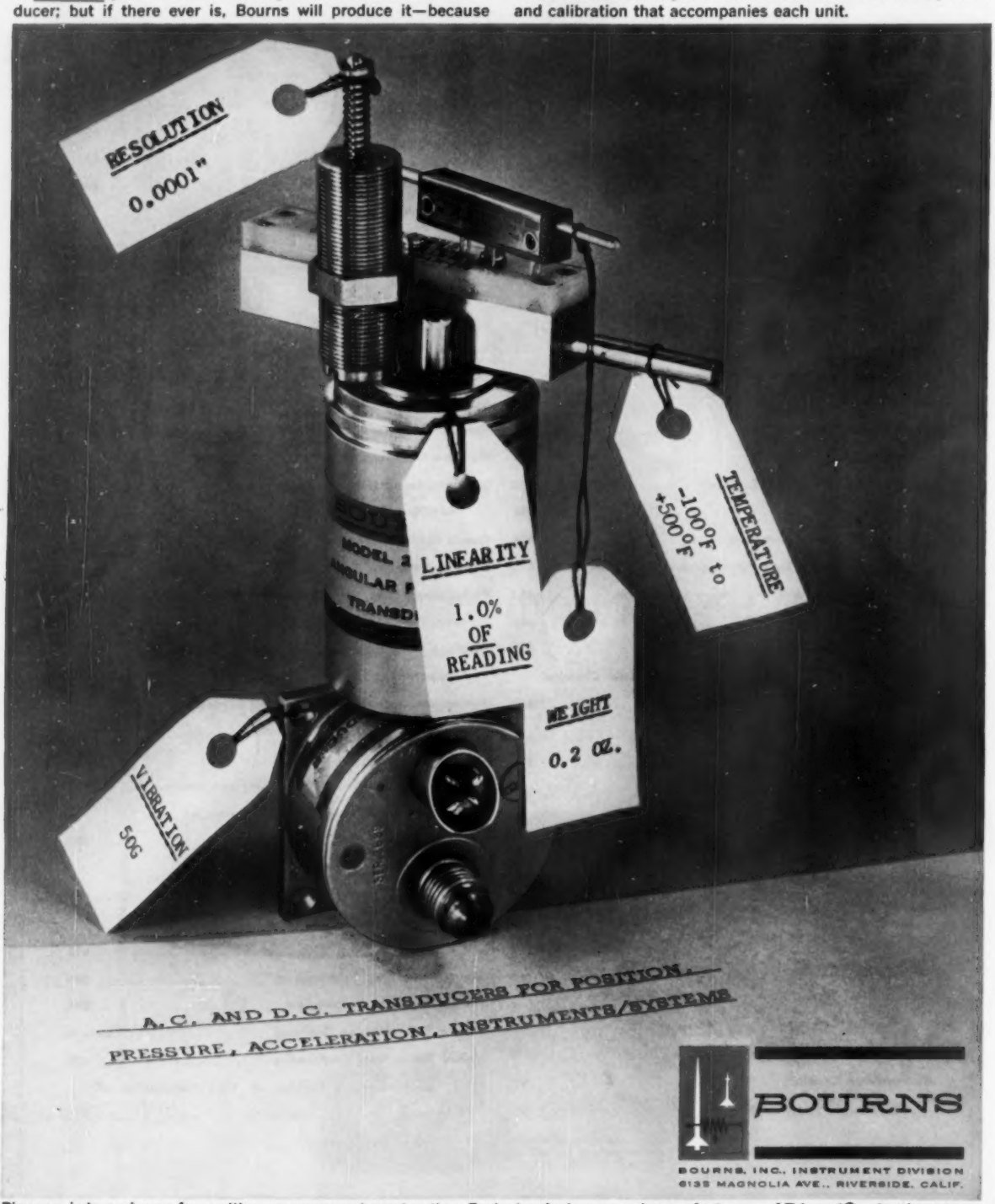

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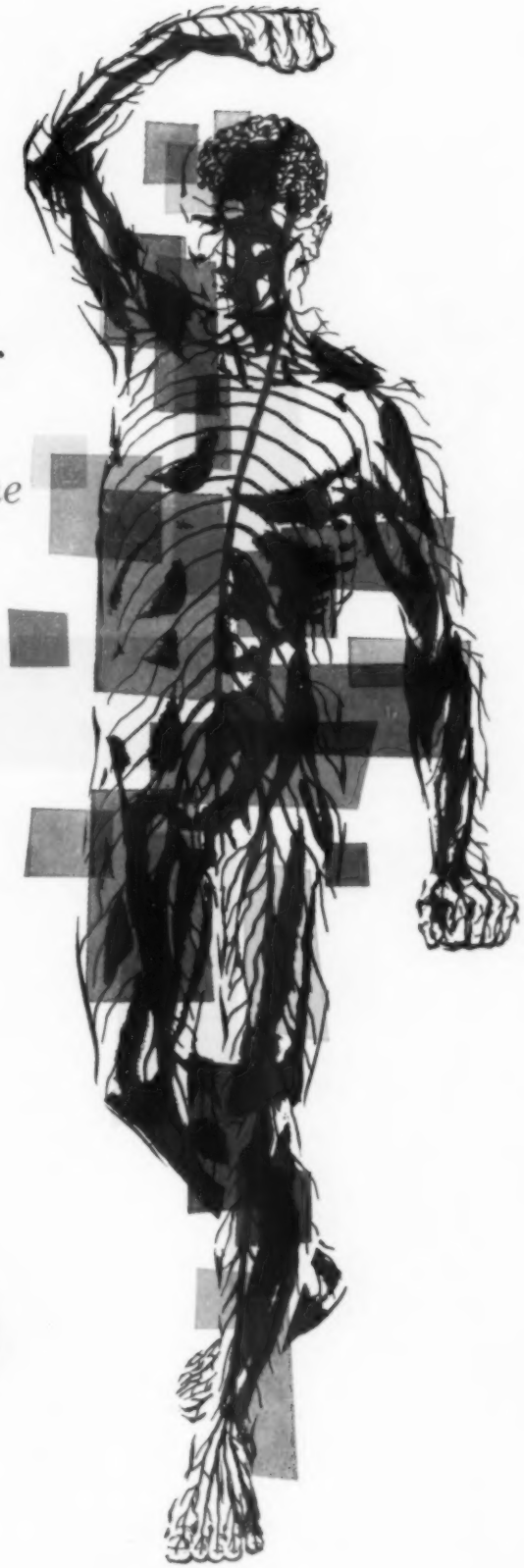

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